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# DESIGN AND CONTROL OF INCINERATORS

## VOLUME II APPENDICES

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16. Abstracts

A versatile batch incinerator was designed and built in order to determine the effect of operational variables on the ignition and burning rates in a fuel bed under conditions similar to those encountered in municipal incinerators. Detailed concentration and temperature profiles within and above the fuel bed were obtained for different distributions of overfire and underfire air rates. These results were used to evaluate both the rate controlling processes and control strategies. It was concluded that for the synthetic refuse beds studied, internal diffusion within the burning elements was limiting and that drying, pyrolysis, and gasification were contemporaneous through most of the runs giving rise to burning rates and overfire gas compositions that were constant over most of a run. From the oxygen concentrations in the bed, it is concluded that low underfire air rates are desirable early and late in a burn, and that for a fully ignited bed the maximum air rate is determined more by consideration of ash carryover and channelling than by the bed's ability to consume the oxygen. The fraction of the heat released above the bed, which determines the overfire air requirements, is governed by the energy requirements of the bed, and decreases with bed moisture and with heat loss from the bed. Towards the end of a burn, the carbon dioxide concentration above the bed falls off dramatically and provides a parameter that could possibly be used for control purposed.

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# FOREWORD

Man and his environment must be protected from the adverse effects of pesticides, radiation, noise and other forms of pollution, and the unwise management of solid waste. Efforts to protect the environment require a focus that recognizes the interplay between the components of our physical environment--air, water, and land. The National Environmental Research Centers provide this multidisciplinary focus through programs engaged in

- studies on the effects of environmental contaminants on man and the biosphere, and

- a search for ways to prevent contamination and to recycle valuable resources.

These appendices are a part of a study that investigated a batch incinerator that was designed and built to determine the effect of operational variables on the ignition and burning rates in a fuel bed. The test conditions were similar to those encountered in municipal incinerators.

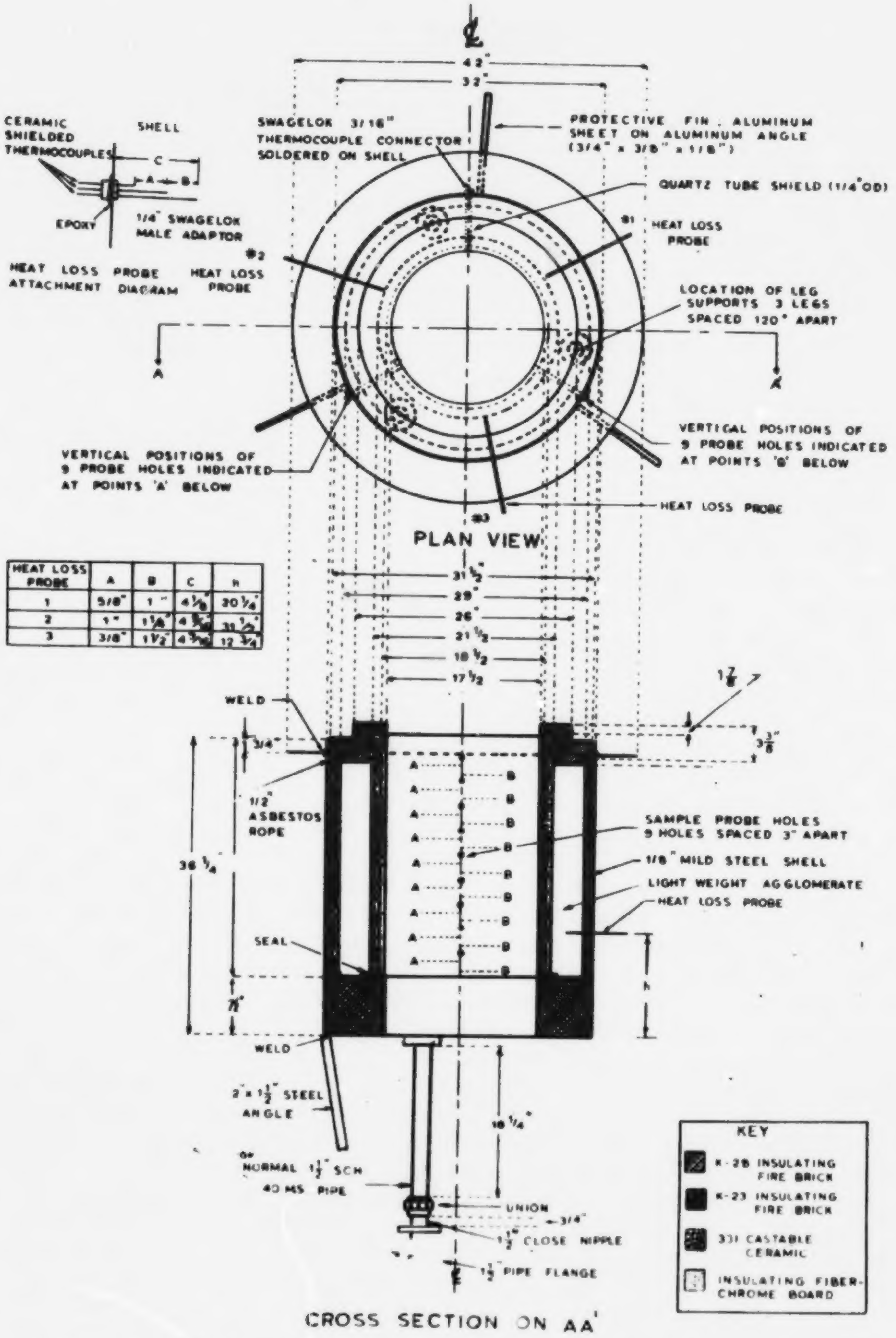
A. W. Breidenbach, Ph.D.
Director
National Environmental
Research Center, Cincinnati

# APPENDIX A

## Detailed Description of Apparatus

Construction of Fuel Bed Section. Figure A.1 shows a cross section and plan view of the part of the apparatus which held the fuel bed. The fuel bed was supported inside the fuel bed section on a grate. This portion of the incinerator was constructed so as to permit extensive temperature and gas measurements within the fuel bed.

A mild steel ring (1/8-inch thick, 31 1/2 inches OD, and 19 inches ID) which supported the internal insulation, was welded onto the bottom of a mild steel shell (1/8-inch wall thickness, 35 inches high and 31 1/2 OD). Inside the steel shell, and resting on the bottom steel support ring, were three layers (7 1/2 inches deep) of Babcock and Wilcox K-23 insulating brick. The bricks were cut to form a hollow cylinder with an 18-inch diameter inside and a 31 1/8-inch diameter outside. Above these bricks, a 1-inch-thick layer of K-23 brick was cemented around the inside surface of the steel shell; this lining extended to within 2 inches of the top of the steel shell. The bricks in the 1-inch lining were cut in an interlocking pattern in order to prevent them from collapsing inwards. A ceramic cylinder, cast from Norton 33I Alundum Insulating castable (30-inch length, 18-inch ID and 21-inch OD), rested on top of the bottom three layers of K-23 brick and was aligned coaxially with the mild steel shell. The ceramic cylinder was locked in place with wedges of brick, and its inside surface was covered with a 1/2-inch layer of Johns Manville Fiberchrome, which has better insulating properties than the 33I castable. The Fiberchrome was bonded to the ceramic with Johns Manville Cera-Kote and its surface made more abrasion-resistant by impregnating it with Johns Manville Cera-Preg. The annular space between the ceramic shell and the brickwork lining was filled with Johns Manville K-24 lightweight aggregate, which has excellent insulating properties. The seal between the top of the ceramic shell and the top of the 1-inch brick lining was formed by a doughnut shaped ring (31 1/4-inch OD and 18-inch ID) constructed from Norton K-28 bricks. As the cross section of Figure A.1 shows, the bricks forming the doughnut were shaped so that they were supported both on the ceramic shell and the 1-inch brickwork lining. A step was cut into the top surface of the brick doughnut which mated with a corresponding step in a similar doughnut in the top section; this method of construction provided a good radiation shield for the flexible diaphragm which joined the two sections of the apparatus together. The bricks forming the doughnut were cemented together on top of a steel support ring. Two ring-


℄
42"
32"
CERAMIC SHIELDED THERMOCOUPLES
SHELL
C
A
B
EPOXY
1/4" SWAGELOK MALE ADAPTOR
HEAT LOSS PROBE ATTACHMENT DIAGRAM
SWAGELOK 3/16" THERMOCOUPLE CONNECTOR SOLDERED ON SHELL
PROTECTIVE FIN, ALUMINUM SHEET ON ALUMINUM ANGLE (3/4" x 3/8" x 1/8")
QUARTZ TUBE SHIELD (1/4" OD)
#1 HEAT LOSS PROBE
#2 HEAT LOSS PROBE
LOCATION OF LEG SUPPORTS 3 LEGS SPACED 120° APART
A
A'
VERTICAL POSITIONS OF 9 PROBE HOLES INDICATED AT POINTS 'A' BELOW
VERTICAL POSITIONS OF 9 PROBE HOLES INDICATED AT POINTS 'B' BELOW
HEAT LOSS PROBE
#3
PLAN VIEW
31 1/2"
29"
26"
21 1/2
18 1/2
17 1/2
1 7/8
3 3/8"
WELD
3/4"
1/2" ASBESTOS ROPE
36 1/4"
SAMPLE PROBE HOLES 9 HOLES SPACED 3" APART
1/8" MILD STEEL SHELL
LIGHT WEIGHT AGGLOMERATE
HEAT LOSS PROBE
SEAL
7"
h
WELD
2" x 1 1/2" STEEL ANGLE
18 1/4"
OR NORMAL 1 1/2" SCH 40 MS PIPE
UNION
3/4"
1 1/2" CLOSE NIPPLE
℄
1 1/2" PIPE FLANGE
KEY
K-28 INSULATING FIRE BRICK
K-23 INSULATING FIRE BRICK
331 CASTABLE CERAMIC
INSULATING FIBER-CHROME BOARD
CROSS SECTION ON AA'

| HEAT LOSS PROBE | A | B | C | h |
|---|---|---|---|---|
| 1 | 5/8" | 1" | 4 1/8" | 20 1/4" |
| 2 | 1" | 1 1/8" | 4 5/16" | 31 1/2" |
| 3 | 3/8" | 1 1/2" | 4 5/16" | 12 3/4" |

Fig. A.1. Cross Section and Plan of Fuel Bed Section

bolts, attached to the support ring, which passed through the bricks, permitted easy removal of the doughnut; when not in use the rings lay in grooves cut into the surface of the bricks. The lower surface of the step was covered with a 1/2-inch layer of Fiberchrome that helped protect the bricks when the two sections of the apparatus were joined together. Thermocouples and gas sample probes were introduced into the fuel bed through any of twenty-seven ports. The ports, arranged in three banks, were spaced 120 degrees apart around the circumference of the outside steel shell. The vertical locations of the ports in each bank were staggered by 1 inch so that they formed a left-hand three-inch pitch spiral around the shell circumference. This arrangement permitted probing at 1-inch intervals throughout the fuel bed. The ports were constructed by first drilling a 1/4-inch-diameter hole through the steel shell, the brick lining and the ceramic cylinder, and then soldering a 3/16-inch Swagelok thermocouple connector fitting into the hole on the outside of the steel shell. In order that the tips of the thermocouples and gas sample probes could be accurately located at the center of the fuel bed, the soldering of the Swagelok connectors was critical, and a special jig was built to locate them in a precise orientation prior to soldering. The construction of the ports was completed by cementing 6-inch lengths of quartz tubing (1/4-inch ID) between the holes in the ceramic shell and the brickwork lining. The quartz tubes, which spanned the annulus filled with agglomerate, prevented the agglomerate from spilling into the fuel bed and facilitated the insertion of the thermocouples and gas sample probes. The probes were protected from accidental physical damage by three fins attached to the sides of the mild steel shell close to the three port locations. The fins also supported the extension leads for the thermocouples, and in addition a junction box for the fuel bed thermocouple connections through to the Data Acquisition System was attached to one of the fins.

Three heat loss probes (see Figure A.1) were located at different vertical and radial positions within the insulating walls so that an estimate could be made of the magnitude of the heat loss through the walls of the fuel bed. Each heat loss probe consisted of three-Chromel Alumel thermocouples cemented into a 1/4-inch M.P.T. to 1/-inch Swagelok fitting, with the beads of each thermocouple separated by a measured distance. The probes were inserted into the insulating walls via holes drilled through the outside steel shell and brick lining and then cemented into place. The positioning of the thermocouple beads was arranged so that they all lay within the annulus filled with the lightweight aggregate.

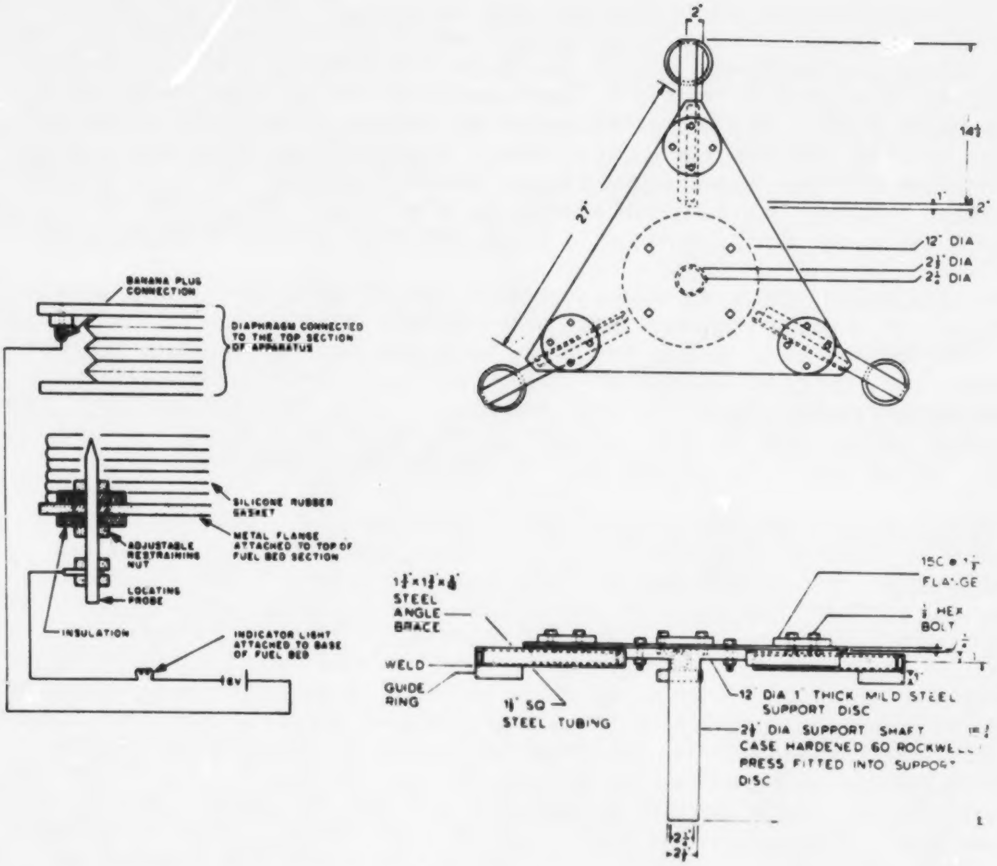
A steel flange (40-inch OD and 31 1/2-inch ID) was welded two inches from the top of the mild steel shell. This flange mated with the flexible diaphragm seal which joined the two sections of the apparatus together. The upper surface of the flange was covered with a number of layers of silicone rubber strip, built up so that there was a good seal between the diaphragm and the flange when they were butted together.

Originally, it was planned to join the two sections of the test incinerator by clamping the diaphragm and the flange together using a set of C-clamps permanently attached to the flange by hinges. Tests on the amount of drag on the weighing system, due to slight distortions of the diaphragm when it was clamped to the flange, showed that this method of joining the two sections of the incinerator together was not desirable. Further tests have shown that an adequate seal was formed, without any noticeable disturbance of the weighing system, if the fuel bed section was positioned so that the rubber seal on the flange just touched the diaphragm.

At three positions on the flange, approximately 120 degrees apart, were placed three "locating probes," whose purpose was to provide a reproducible method of locating the bottom section underneath the top section. These probes, shown schematically in Figure A.2(a), were mounted perpendicular to the surface of the flange with the tips of the probes lying just below the surface of the sponge rubber seal. A screw adjustment and locking nut were provided for each probe so that it could be set to any desired height. One side of an electrical circuit was connected in parallel with each probe, while the other side was attached to the diaphragm seal. When the probe touched the diaphragm, an indication light, located on the movable base and connected in series with the probe, was activated.

The fuel bed section was mounted on three legs (1 1/2-inch-diameter mild steel pipe) attached by means of a 1 1/2-inch by 150-lb flange located at 120-degree intervals around the steel ring welded to the bottom of the steel shell. Each leg was divided into two sections; the bottom portion of each leg, a close 1 1/2-inch nipple, was screwed into a flange attached to a base which supported the fuel bed section. When the fuel bed section was mounted onto the support base, the two portions of each leg were joined together with a union.

Support base for Fuel Bed Section. This part of the apparatus, shown in Figure A.2(b), supported the fuel bed section along with the hydraulic jack and grate assembly. On the lower surface of the base was a shaft which passed through two linear


BANANA PLUG CONNECTION
DIAPHRAGM CONNECTED TO THE TOP SECTION OF APPARATUS
SILICONE RUBBER GASKET
METAL FLANGE ATTACHED TO TOP OF FUEL BED SECTION
ADJUSTABLE RESTRAINING NUT
LOCATING PROBE
INSULATION
INDICATOR LIGHT ATTACHED TO BASE OF FUEL BED
6V
2"
14½
1"
2"
27"
12" DIA
2½" DIA
2¼" DIA
1½"×1½"×⅛" STEEL ANGLE BRACE
WELD
GUIDE RING
1½" SQ STEEL TUBING
15C ● 1" FLANGE
½ HEX BOLT
12 DIA 1" THICK MILD STEEL SUPPORT DISC
2½" DIA SUPPORT SHAFT
CASE HARDENED 60 ROCKWELL
PRESS FITTED INTO SUPPORT DISC
2¼"
2½"

(a) (b)

Fig. A.2. (a) Schematic of Locating Probe;
(b) Plate for Fuel Bed Section

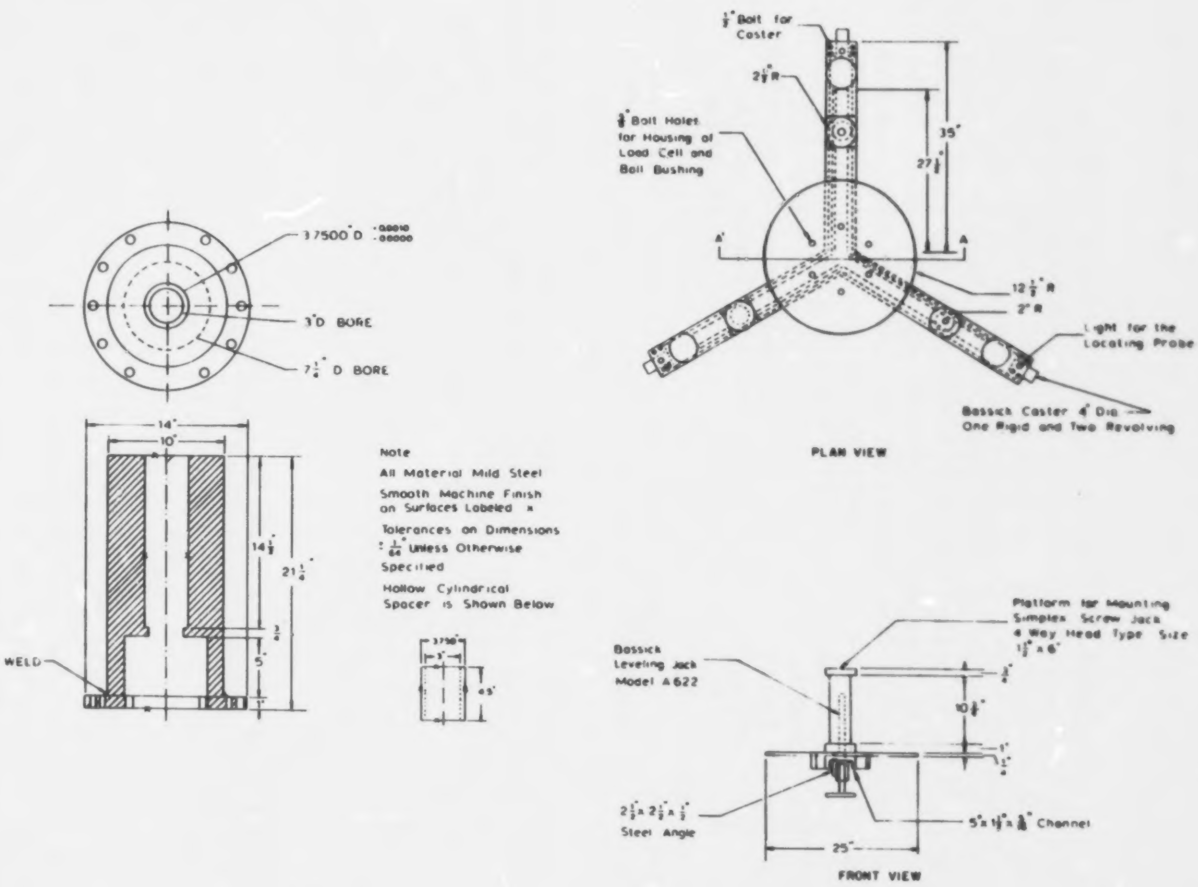
ball bushings, held in a special housing, and then rested on the load cell. The total weight of the fuel bed section and support base was thus transmitted to the load cell.

At the three vertices of the triangular base plate were bolted three 1 1/2-inch by 150-lb flanges into which the bottom portions of the fuel bed section legs were screwed. At the center of the base plate was bolted a 1-inch-thick by 12-inch-diameter mild steel plate which had a 2 1/2-inch-diameter by 16 3/4-inch-long 60 Rockwell case hardened shaft press fitted axially into it. The base plate was mounted in place by passing the case hardened shaft through two linear ball bushings held in a special housing, and resting it on the load cell. The base plate was strengthened at three locations by angle iron welded to its undersurface. Protruding from the three vertices of the base were three short lengths of 1 1/2-inch square tubing, at the ends and on the lower surfaces of which were welded locating rings for the support jacks.

The hydraulic jack assembly which supported the grate was bolted to a rectangular support plate, which was in turn bolted to the base plate with two 1/2-inch bolts. The jack support plate had slotted holes so that the jack could be aligned coaxially with the fuel bed section. The hydraulic jack permitted the grate to be raised or lowered so that fuel bed depths of from eight to thirty inches could be studied.

Bearing and Load Cell Housing. This part of the apparatus, shown in Figure A.3(a), held the two linear ball bushings and housed the load cell. The top portion of the housing contained two TEK 2 1/2-inch-bore linear ball bushings which were separated by a 4 1/2-inch spacer. The bushings were press-fitted into their housing and supported in place by a small lip that separated the bushing and load cell housings. The spacing between the bushings helped distribute the lateral thrust experienced by the bushings due to eccentric loads. The housing was bolted in place on the movable base over the load cell. Because the alignment of the housing and the load cell was critical, the position of the housing was adjusted so that its center was within ±1/16 inch of the center of the load cell load button before it was bolted down.

The load cell (Baldwin, Lima and Hamilton C3PI) was bolted to a 7-inch square by 3/4-inch thick mild steel plate using the tapped hole, supplied by the manufacturer, in the base of the load cell. This plate was bolted to the center of the movable base with four 3/8-inch bolts located at each of its corners. The elctrical connections to the load cell were made through a hole in the side of the housing.


37500" D +.00010 -.00000
3" D BORE
7 1/4" D BORE
14"
10"
14 1/8"
21 1/4"
3/4
5"
1"
WELD
Note
All Material Mild Steel
Smooth Machine Finish on Surfaces Labeled x
Tolerances on Dimensions ± 1/64" Unless Otherwise Specified
Hollow Cylindrical Spacer is Shown Below
3750"
3"
4.5"
1/2" Bolt for Caster
2 1/2" R
3/8" Bolt Holes for Housing of Load Cell and Ball Bushing
35"
27 1/2"
A'
A
12 1/2" R
2" R
Light for the Locating Probe
Bassick Caster 4" Dia One Rigid and Two Revolving
PLAN VIEW
Platform for Mounting Simplex Screw Jack 4 Way Head Type Size 1 1/2" x 6"
Bassick Leveling Jack Model A622
3/4"
10 1/4"
1"
1/4"
2 1/2" x 2 1/2" x 1/2" Steel Angle
5" x 1 1/2" x 3/8" Channel
25"
FRONT VIEW

(a) (b)

Fig. A.3. (a) Bearing Housing; (b) Movable Base for Fuel Bed Section

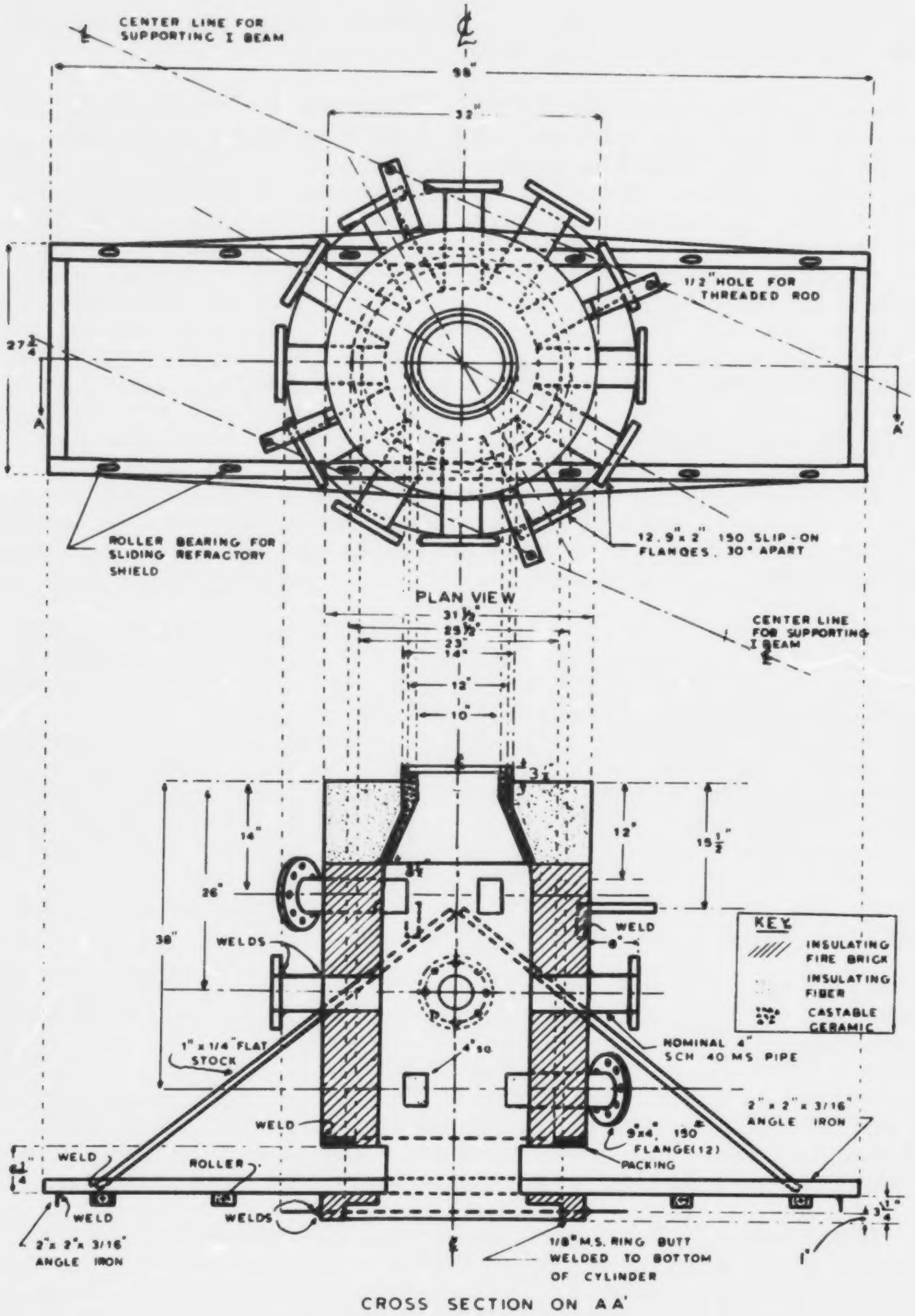
A spirit level was mounted on the top surface of the housing mounting flange and was used for leveling the bottom section of the apparatus.

Movable Base. This part of the equipment, shown in Figure A.3(b), supported the whole bottom portion of the apparatus and provided a convenient means of moving it about. The movable base consisted of a circular steel disk 3/8-inch thick and 26 inches in diameter from which three arms radiated, each 33 inches long and spaced 120 degrees apart. A Bassick leveling jack and rubber wheel were located at the end of each arm. The Bassick jacks were used for leveling the bottom half of the equipment and for raising and lowering it so that it could be joined to and removed from under the top half. About halfway down the arms towards the center of the circular disk another three jacks (Simplex screw jacks) were mounted, the tops of which engaged with the locating rings on the support base for the fuel bed section. These jacks were used to raise the fuel bed section of the load cell when the apparatus was not in use, and they helped protect the ball bushings by providing support for the fuel bed section when the bottom portion of the apparatus was being moved about.

The underside of the movable base was strengthened with lengths of angle iron as it was important that there be minimum flexure of the base when the fuel bed section was lowered onto the load cell. The movement of the base was constrained by a set of rails, and this arrangement, along with a suitable stop, allowed the bottom half of the apparatus to be reproducibly located underneath the top section. A handle was attached at the end of one of the arms to facilitate moving the bottom half of the apparatus smoothly.

Construction of Overfire Combustion Section. The top half of the apparatus is shown in plan and cross section in Figure A.4. This section provided the overfire volume required for the burn-out of volatiles, smoke, and carbon particles.

The shell of this section consisted of a 1/4-inch-thick mild steel cylinder 31 1/2 inches OD and 48 inches in length with two 6-inch deep slots cut in the side to permit the passage of the sliding refractory shield. This shield moved in a plane perpendicular to the axis of the shell. Movement of the shield was facilitated by two guides, constructed from lengths of angle iron, which were welded to the two bottom corners of the slots so that they passed through the interior of the shell and overhung each side. Angle iron sections were welded to the ends of these guides to give them extra rigidity. The guides were supported by four stays, which



CENTER LINE FOR SUPPORTING I BEAM
℄
38"
32"
27 3/4
A
A'
1/2" HOLE FOR THREADED ROD
ROLLER BEARING FOR SLIDING REFRACTORY SHIELD
12. 9" x 2" 150 SLIP-ON FLANGES, 30° APART
PLAN VIEW
31 1/2"
29 1/2"
23"
14"
12"
10"
CENTER LINE FOR SUPPORTING I BEAM
3 1/2
14"
26"
38"
12"
15 1/2"
3 1/2
WELDS
WELD
8"
KEY
INSULATING FIRE BRICK
INSULATING FIBER
CASTABLE CERAMIC
1" x 1/4" FLAT STOCK
4" SQ
NOMINAL 4" SCH 40 MS PIPE
WELD
2" x 2" x 3/16" ANGLE IRON
9"x4" 150# FLANGE(12)
PACKING
WELD
ROLLER
6 1/4"
WELD
WELDS
2" x 2" x 3/16" ANGLE IRON
1/8" M.S. RING BUTT WELDED TO BOTTOM OF CYLINDER
3 1/4"
1"
CROSS SECTION ON AA'

Fig. A.4. Cross Section and Plan of Overfire Section

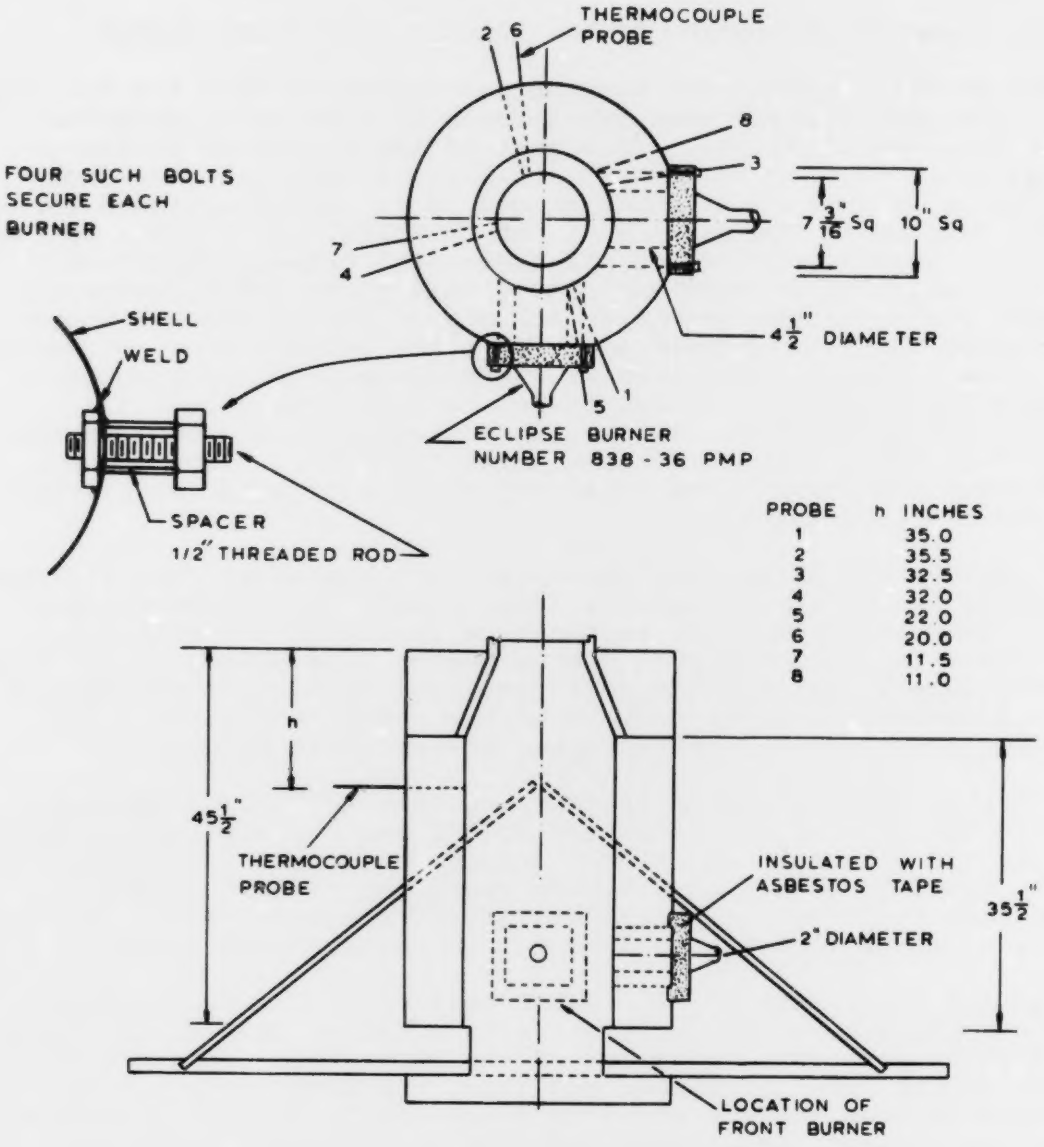
were welded to the ends of the guides and to the steel shell. Small rollers were placed at intervals along the guides and helped the shield move smoothly.

Twelve 4-inch-diameter ports were located at three vertical positions around the circumference of the steel cylinder between the shield and a plane 14 inches from the top of the shell. Four ports, diametrically opposed, were located at each vertical position and were offset 30 degrees from the ports located in the levels adjacent. The ports were constructed from nominal 4-inch mild steel pipe and were each 6 inches in length. One end of the pipe was welded over a 3 1/2-inch hole cut in the side of the main steel shell, while a 150-lb flange was welded to the other end. In addition to the ports, two 7-inch square holes 90 degrees apart were cut in the side of the shell, a few inches above the sliding shield, to accommodate the two gas burners. The location of the burners and the method of attaching them to the shell are shown in Figure A.5. A 1/8-inch-thick mild steel flange was welded around the outside and close to the bottom of the steel shell; the flexible diaphragm seal was connected to this flange with C-clamps.

The inside of the shell, above the shield and within 8 1/2 inches of the top, was lined with 6 1/2 inches of Babcock and Wilcox K-28 insulating refractory brick. This arrangement left an 18-inch-diameter overfire region. Suitable holes were cut in this brickwork to accommodate the gas burners and overfire air nozzles. The brickwork was supported by a steel ring welded inside the steel shell just above the slots cut for the shield. The bottom layer of bricks in this section of brickwork was cut with a small lip such that they overhung the steel ring and reached down close to the top of the sliding shield. The small space left between the support ring and the shield was filled with Fiberchrome.

A ceramic dome, cast from Norton 33I insulating castable, in the shape of a truncated cone rested on top of the brickwork lining. The cone narrowed the combustion region cross section down to a 10-inch diameter over a vertical distance of 12 inches and provided a transition between the overfire combustion region anf the flue stack. The cone was held in place with refractory cement and brick wedges. The space between the shell and the cone was filled with Johns Manville Cera-fiber.

Below the shield, there was one layer of refractory bricks supported by a mild steel ring which was butt-welded to the bottom of the steel shell. These bricks were cut to form an L-shaped cross section so that they mated with the corresponding bricks in the fuel bed section. The top surfaces of these bricks



| PROBE | h INCHES |
|---|---|
| 1 | 35.0 |
| 2 | 35.5 |
| 3 | 32.5 |
| 4 | 32.0 |
| 5 | 22.0 |
| 6 | 20.0 |
| 7 | 11.5 |
| 8 | 11.0 |

Fig. A.5. Thermocouple and Gas Burner Locations in the Overfire Section

lay close to the bottom of the sliding refractory shield.

The overfire combustion section was supported from the ceiling of the test cell between two I-beams by four bolts attached to four I-beam clamps. This part of the apparatus butted against a 32-inch by 48-inch metal plate that had a 36-inch-long by 14-inch ID cylinder welded to it, which extended through the ceiling to the outside of the building. A silicone sponge rubber gasket provided an air-tight seal between these two sections. The outside surface of this plate and cylinder assembly was wrapped with 3/8-inch copper tubing through which cooling water was pumped to protect the ceiling from overheating. On the inside of the cylinder was a 10-inch-ID, 12-inch-OD ceramic cylinder 36 inches in length cast from Norton 33I castable refractory. This cylinder rested in a groove in the ceramic dome, where it formed a gas-tight seal. The space between the ceramic and steel cylinders was packed with Johns Manville Cera-fiber.

Eight Chromel-Alumel thermocouples were placed at four different levels around the refractory (just inside the inside surface) and used to monitor the temperature levels of the refractory. Three more Chromel-Alumel thermocouples were placed at different positions on the outside shell and used to monitor the change in temperature gradients through the refractory walls. The locations of these thermocouples are shown in Figure A.5.

A double layer of asbestos tape was fastened around the gaps between the sliding refractory shield and the steel shell to minimize air leakage. A heat shield was placed just above the sliding shield on the side where the red-hot shield emerged from the shell at the start of the experiment, and served to protect the equipment from radiant heat damage.

Sliding Refractory Shield. This portion of the top half of the apparatus, shown in Figure A.6, acted as an "on/off" gate valve between the two halves of the apparatus. When the shield was in the "off" or closed position, the bottom section was isolated from the top section, which could then be preheated to the desired temperature with the gas burners. With the shield in the "on" or open position, the two parts of the incinerator were "joined" together, allowing the radiant heat flux to ignite the fuel bed and start the combustion process. The basic construction of the shield consisted of an angle iron frame 64 1/8 inches by 27 3/4 inches by 5 1/2 inches high which slid easily along the guide rails and through the slots of the overfire combustion section. The bottom of the frame was braced with flat stock to help support the insulation. The shield was divided into two halves. One side had a 3/8-inch-diameter copper cooling coil tied to the bottom

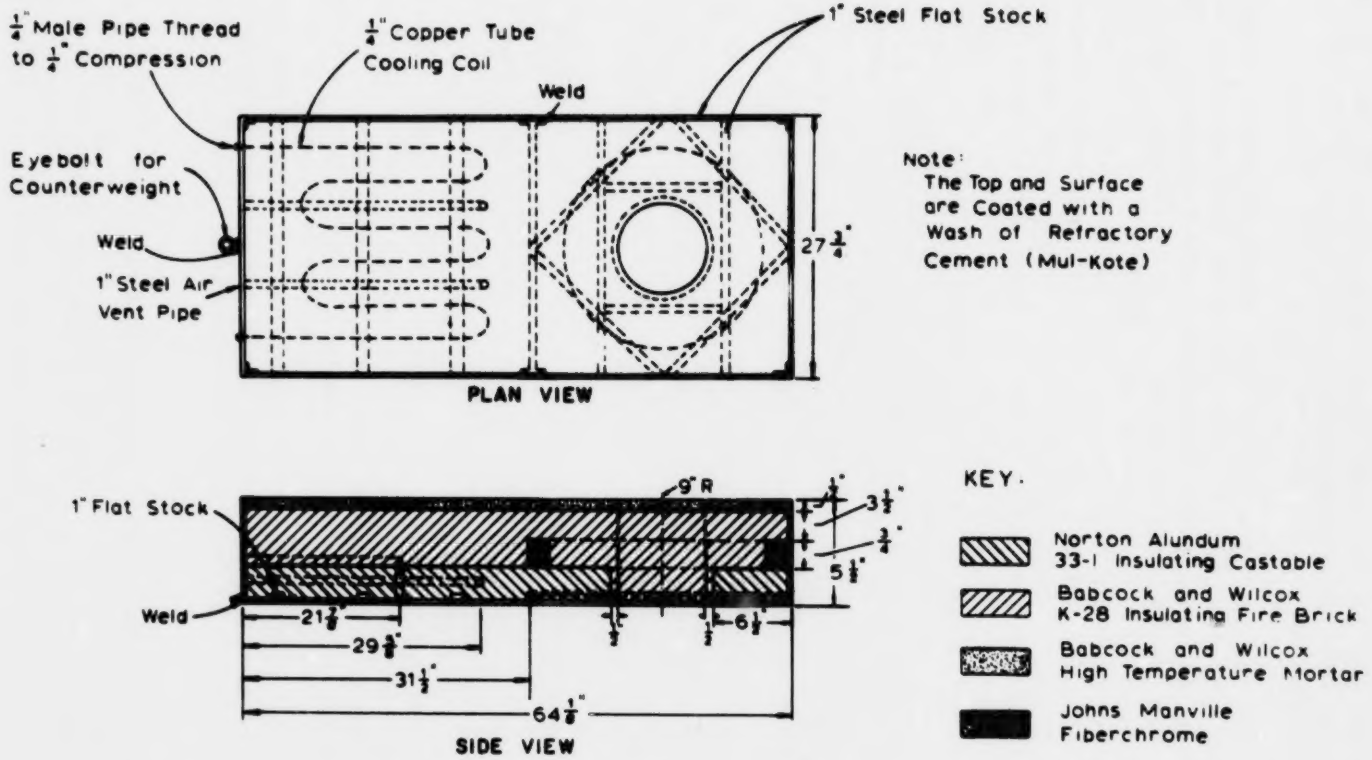

$\frac{1}{4}$" Male Pipe Thread to $\frac{1}{4}$" Compression
$\frac{1}{4}$" Copper Tube Cooling Coil
1" Steel Flat Stock
Weld
Eyebolt for Counterweight
Weld
1" Steel Air Vent Pipe
27$\frac{3}{4}$"
PLAN VIEW
Note: The Top and Surface are Coated with a Wash of Refractory Cement (Mul-Kote)
1" Flat Stock
Weld
9" R
$\frac{1}{2}$"
3$\frac{1}{2}$"
$\frac{3}{4}$"
5$\frac{1}{2}$"
21$\frac{7}{8}$"
29$\frac{5}{8}$"
31$\frac{1}{2}$"
64$\frac{1}{8}$"
$\frac{1}{2}$
$\frac{1}{2}$
6$\frac{1}{2}$"
SIDE VIEW
KEY.
▨ Norton Alundum 33-1 Insulating Castable
▨ Babcock and Wilcox K-28 Insulating Fire Brick
▒ Babcock and Wilcox High Temperature Mortar
■ Johns Manville Fiberchrome

Fig. A.6. Sliding Refractory Shield

braces and a 1-inch-thick layer of Norton 33I castable cast over and around it. The two ends of the cooling coil protruded through the angle iron frame and were fitted with 1/4-inch M.P.T. to 1/4-inch compression fittings, thus enabling them to be connected to the cooling water supply.

In addition to the cooling coil, two exhaust ports, which permitted the escape of air from the fuel bed section when the shield was closed, were embedded in the ceramic. On top of the castable was placed a layer of K-28 brick, the top surface of which was flush with the top of the angle iron frame. The surface of the bricks was washed with a protective coating of Babcock and Wilcox Mul-Kote refractory cement. In the bottom of the shield's other half, there was another 1-inch-thick layer of ceramic, cast so that an 18-inch-diameter hole was left in it at the center of the half. On top of the castable was a layer of K-28 bricks, shaped so that they also left an 18-inch-diameter hole in the center of this half, which came up flush with the top of the angle iron frame. These bricks were also washed with a protective layer of Mul-Kote. The positioning of the 18-inch-diameter hole was fixed so that when the shield was in the open position the hole aligned closely with the overfire region of the top section.

At the cooling coil end of the shield, an eyebolt was welded to the bottom section of the angle iron frame. One end of a cable was attached to this eyebolt, while the other end passed over a pulley attached to a wall and was then fixed to a counterweight used as an aid in moving the shield.

Overfire Air Nozzles. The design basis of air nozzles for the adequate mixing of the overfire air and the products of combustion was largely empirical. No attempt was made to study the effect of different nozzle configurations; however, the flange system provided for installing the nozzles allowed for many different nozzle arrangements to be used. The present system permitted the use of nozzles up to a nominal 2-inch diameter. The nozzles were held with a set screw in a 9-inch by 2-inch, 150-lb threaded reducing flange bored to accept a nominal 2-inch pipe. Nozzles of smaller diameter were fitted with a bushing such that they could be held by these reducing flanges. The nozzles now being used consisted simply of 2-inch-diameter mild steel pipe aimed axially into the overfire area.

Stack. The flue gases were directed away from the roof by means of a 10-foot-high stack made from 14-gauge sheet metal. The stack consisted of a 12-inch-diameter cylinder 8-feet high, with a truncated cone having a 36-inch-diameter base welded onto one end. The other end of the stack had three loops tack-welded to it 120 degrees apart and was covered with a round rain cap. Four legs were welded down the side of the cone section, the legs being shaped so that they met the roof vertically. The legs were bolted to an angle iron frame which was securely attached to the roof. Guy lines were attached to the three loops at the top of the stack and bolted down firmly at the other end to eyebolts attached to suitable anchors on the roof. The various probes (temperature, gas composition and smoke) passed through the conical section of the stack and their tips were located in the center and a few inches into the ceramic cylinder leading from the overfire combustion section. The probes passed through suitable fittings, soldered to the stack, which permitted them to be easily removed.

The stack was positioned so that the end of the ceramic cylinder from the overfire section lay about 8 inches below the bottom of the narrow end of the truncated cone. This arrangement allowed a certain amount of air to be drawn into the stack to cool the flue gases. Two hinges were used to anchor the stack to the angle irom support frame; thus, it could be lowered easily for the removal or installation of other equipment.

## APPENDIX B

## Heat Loss Through Fuel Bed Wall

**Estimate of Heat Loss Through Walls.** The fuel bed section can be modeled as an infinite hollow cylinder of inner diameter 2a and outer diameter 2b. The equation describing the conduction of heat in this system is

$$\frac{\partial^2 T}{\partial r^2} + \frac{1}{r}\frac{\partial T}{\partial r} - \frac{1}{\alpha}\frac{\partial T}{\partial t} = 0, \quad a \leq r \leq b, \quad t > 0 \qquad \text{(B-1)}$$

where $\alpha$, the thermal diffusivity, $= \frac{k}{\rho C_p}$

and $k$ = thermal conductivity

$\rho$ = density

$C_p$ = heat capacity

The boundary conditions which approximately describe the system of interest are

$$\text{(i)} \quad T = T_0, \quad r = b, \quad t > 0 \qquad \text{(B-2)}$$

$$\text{(ii)} \quad T = T_1, \quad r = a, \quad t > 0 \qquad \text{(B-3)}$$

$$\text{(iii)} \quad T = T, \quad a \leq r \leq b, \quad t = 0 \qquad \text{(B-4)}$$

where $T_1$ is the temperature of the burning fuel bed. The first boundary condition should, more properly, be written

$$-k\frac{\partial T}{\partial r}\bigg|_{r=b} = h(T-T_0) \qquad \text{(B-5)}$$

but the boundary condition chosen represents a "worst" case and is applicable during the short times of interest in this problem. Equation (B-1) may be placed in dimensionless terms by defining

a dimensionless temperature, $\theta = \dfrac{T - T_0}{T_1 - T_0}$; (B-6)

a dimensionless radius, $R = \dfrac{r}{a}$; (B-7)

and a dimensionless time, $\tau = \dfrac{t\alpha}{a^2}$; (B-8)

The equation of interest is then transformed into

$$\frac{\partial^2\theta}{\partial R^2} + \frac{1}{R}\frac{\partial\theta}{\partial R} - \frac{\partial T}{\partial\tau} = 0 \qquad \text{(B-6)}$$

with

$$\theta = 0 \ , \ R = \frac{b}{a} = \zeta \ , \ \tau = 0 \qquad \text{(B-10)}$$

$$\theta = 1 \ , \ R = 1 \ , \ \tau > 0 \qquad \text{(B-11)}$$

$$\theta = 0 \ , \ 0 \leq R \leq 1 \ , \tau = 0 \qquad \text{(B-12)}$$

Taking the Laplace transform of (B-9) gives

$$\frac{d^2\overline{\theta}}{dR^2} + \frac{1}{R}\frac{d\overline{\theta}}{dR} - s\overline{\theta} = 0 \qquad \text{(B-13)}$$

while the boundary conditions transform into

$$\overline{\theta} = \frac{1}{s} \ , \quad R = 1 \qquad \text{(B-14)}$$

$$\overline{\theta} = 0 \ , \quad R = \frac{b}{a} = \zeta \qquad \text{(B-15)}$$

The solution to (B-13), which is a modified Bessel's equation of order zero, is of the form

$$\overline{\theta} = AI_0(qR) + BK_0(qR) \qquad \text{(B-16)}$$

where

$$q^2 = s \qquad \text{(B-17)}$$

Using the two boundary conditions (B-14) and (B-15) to eliminate A and B gives

$$sF(g)\overline{\theta} = K_0(g\zeta)I_0(qR) - I_0(q)K_0(qR) \qquad \text{(B-18)}$$

where

$$F(q) = K_0(q\zeta)I_0q - K_0(q)I_0(q\zeta) \qquad \text{(B-19)}$$

or, using the relationship between $I_0$ and $J_0$ and $K_0$ and $Y_0$ and $J_0$,

$$F(q) = Y_0(q)J_0(q\zeta) - J_0(q)Y_0(q\zeta) \qquad \text{(B-20)}$$

Using the inversion theorem $\theta$ is found to be

$$\theta = 1 - \frac{\log_e R}{\log_e} + \Pi\sum_{n=1}^{\infty} e^{-\beta_n^2\tau} \frac{J_0^2(\zeta\beta_n)\{J_0(R\beta_n)Y_0(\beta_n) - Y_0(\beta_a R)J_0(\beta_n)}{J_0^2(\beta_n) + J_0^2(\beta_n\zeta)} \qquad \text{(B-21)}$$

where $\beta_n$ are the roots of $Y_0(q)J_0(q\zeta) - J_0(q)Y_0(q\zeta)$.

The flux q leaving at r = a is found as follows

$$q = -2\pi k(T_1 - T_0)\frac{\partial\theta}{\partial R}\bigg|_{R=1} \qquad \text{(B-22)}$$

and the accumulative heat loss per unit height, Q, is given by

$$Q = -2\pi k(T_1 - T_0)\int_0^t \frac{\partial\theta}{\partial R}\bigg|_{R=1} \partial t \qquad \text{(B-23)}$$

Thus,

$$Q = 2\Pi k(T_1 - T_0)\left[\frac{t}{\log_e \zeta} + \frac{a^2\pi}{\alpha}\sum_{n=1}^{\infty}\frac{A_n}{\beta_n}\left(1 - \exp\left\{\frac{-\beta_n^2\alpha t}{a^2}\right\}\right)\right] \qquad \text{(B-24)}$$

where

$$A_n = J_0^2(\zeta\beta_n)\,\frac{Y_0(\beta_n)J_1(\beta_n) - J_0(\beta_n)Y_1(\beta_n)}{J_0^2(\beta_n) + J_0^2(\zeta\beta_n)} \qquad \text{(B-25)}$$

A plot of Q as a function of time is shown in Figure B.1 for different values of k, $\rho$ and $C_p$. The upper values of k, $\rho$ and $C_p$ represent a very pessimistic estimate of the thermal properties of the fuel bed walls, while the low values are thought to be closer to reality. For these plots $T_1 - T_0$ was assumed to be 1900°F. The values of Q must be compared to the heat liberation rate within the bed. With a burning rate of 70 lb $hr^{-1}$, a packed density of 10 lb $ft^{-3}$ and a heat of combustion of 6,500 Btu $lb^{-1}$, the heat generated per foot depth over a period of a quarter of an hour is approximately $10^5$ Btu.

Criterion for Minimizing Heat Loss. From equation (B-24), Q is minimized when (i) k is made as small as possible and (ii) the contribution of the term

$$\frac{a^2\pi}{\alpha}\left\{\sum_{n=1}^{\infty}\frac{A_n}{\beta_n}\left(1 - \exp\left\{-\frac{\beta_n^2\alpha t}{a^2}\right\}\right)\right\}$$

is minimized. The latter condition is seen to be met when

$$\frac{\beta_n^2\alpha t}{a^2} << 1 \quad \text{or } \alpha << 1$$

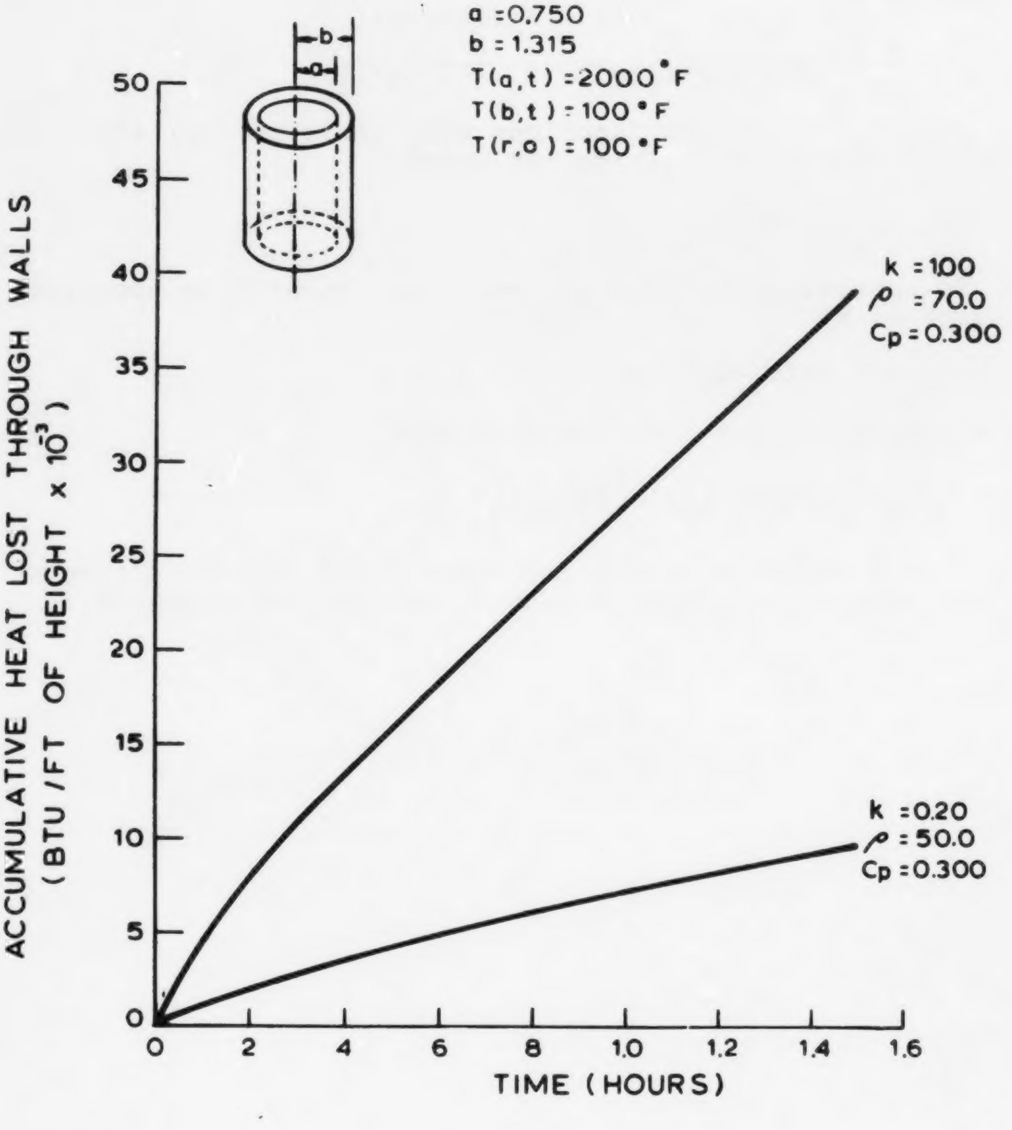


Fig. B.1. Estimate of Accumulative Heat Loss Through Fuel Bed Walls

However, these conditions say nothing about the thermal inertia term $\rho C_p$.

The criterion for minimum heat loss is best obtained from equation (B-16)

$$\bar{\theta} = \frac{K_0(q\zeta)I_0(qR) - I_0(q)K_0(qR)}{S[K_0(q\zeta)I_0(q) - K_0(q)I_0(q\zeta)]}$$

and replacing the Bessel functions with their appropriate asymptotic expansions, giving the result

$$\bar{\theta} = \frac{e^{q(R-1)}}{s} [1 + \ldots]$$

which is approximately true for small $\tau$. Hence $\theta$ is approximately given by

$$\theta = \mathrm{erfc}\frac{a(R-1)}{2\sqrt{\alpha t}} + \ldots$$

from which it follows that the heat loss

$$q = A\sqrt{k\rho C_p} \exp -\left[\frac{A(R-1)}{2\sqrt{\alpha t}}\right]$$

where A is a proportionality constant. This result indicates that the product $k\rho C_p$ should be kept as small as possible.

# APPENDIX C

## Fuel Bed Weighing System

**Theory of Load Cell Operation.** Load cells are electronic transducers which translate changes in force into changes in voltage. Typically they are constructed by bonding four matched strain gauges to a precision-machined steel support; the strain gauges are connected to form a balanced Wheatstone bridge. In addition, resistors are added to the circuit to help maintain bridge accuracy over a wide temperature range. The principle of operation depends upon the deflection of the strain gauge filament creating change in its resistance, thereby unbalancing the bridge circuit. A standard circuit for a load cell is shown in Figure C.1

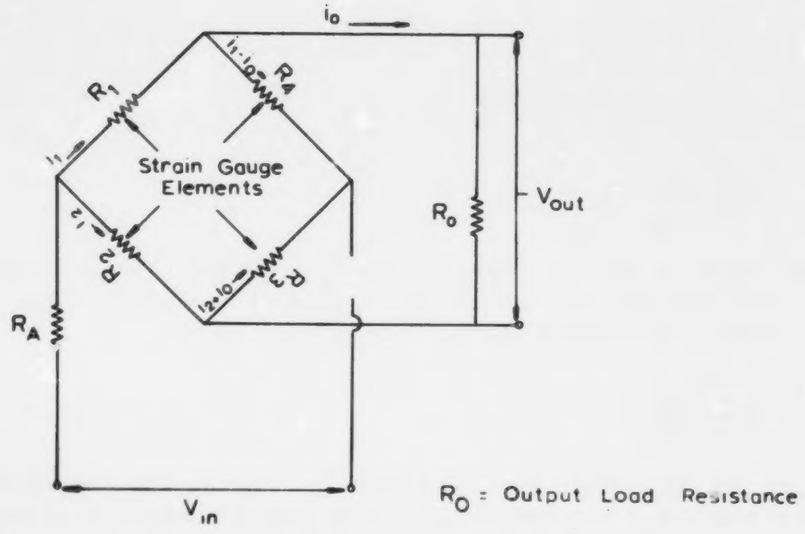


Fig. C.1. Load Cell Circuit diagram.

Using Kirchhoff's second law the following equations can be written

$$R_1 i_1 + R_4(i_1 - i_o) = V_{in} \qquad \text{(C-1)}$$

$$R_1 i_1 + R_o i_o - R_2 i_2 = 0 \qquad \text{(C-2)}$$

$$R_o i_o + R_3(i_2 + i_o) - R_4(i_1 - i_o) = 0 \qquad \text{(C-3)}$$

where $V_{in}$ is the input voltage to the bridge circuit and $R_j$ the resistance of, and $i_j$ the current through strain gauge j. These equations can be solved to give the current through the load resistance $R_o$; the result is

$$i_o = \frac{V_{in}(R_2R_4 - R_1R_3)}{R_2(R_1 + R_4)(R_o + R_3 + R_4) + R_1R_3R_4 - R_2R_4^2 + R_oR_3(R_1 + R_4)} \qquad \text{(C-4)}$$

Threating a simple case in which all four legs of the Wheatstone bridge have the same resistance R, for a small change ΔR in the resistance of one leg equation (C-4) can be reduced to

$$i_o = \frac{V_{in}\Delta R}{4R(R + R_o)} \qquad \text{(C-5)}$$

Now, the ratio $\frac{\Delta R}{R}$ is also given by

$$\frac{\Delta R}{R} = \eta\frac{\Delta L}{L} = \eta\varepsilon \qquad \text{(C-6)}$$

where $\eta$ is the strain gauge factor and $\frac{\Delta L}{L}$ the strain experienced by the structured member to which the gauge is bonded when it is loaded. Combining equations (C-5) and (C-6) gives

$$i_o = \frac{n \; V_{in} \; \varepsilon}{4(R + R_o)} \qquad \text{(C-7)}$$

More generally, if all four resistances in the bridge circuit are allowed to change incrementally. the output signal (when all four gauges have the same nominal resistance R) is,

$$V_{out} = \frac{V_{in}}{4(1 + \frac{R}{R_o})} \quad \frac{\Delta R_1}{R_1} - \frac{\Delta R_2}{R_2} + \frac{\Delta R_3}{R_3} - \frac{\Delta R_4}{R_4} \qquad \text{(C-8)}$$

Equation (C-7) gives three important results: (a) the output voltage is attenuated as $R_o$ decreases; (b) the output voltage is directly proportional to the applied load; (c) the output voltage is directly proportional to the input voltage to the bridge circuit. In practice, therefore, to achieve the maximum sensitivity of the load cell, the output load resistance should be large (i.e., $R_o >> R$) and the input voltage to the bridge should be as high as possible without allowing so much current to pass through the strain gauge elements that they heat up.

Load Cell Specifications. The load cell used was a BLH Precision C3P1 Load Cell; full specifications are given in Table C.I. The load cell bridge was activated with 12 volts dc from a Hewlett-Packard dc power supply, 6216A. The input voltage, as well as the millivolt output of the bridge, was connected through to the Data Acquisition System.

Selection of Weighing System. Three distinct arrangements can be suggested for weighing the fuel bed section using load cell techniques.

(1) Three load cells located at three points on a base which supports the fuel bed section; the center of gravity of the fuel bed section lying within the triangle formed by the load cells.

(2) One load cell located at only one point in the system described in (1), with the other two points being mounted on suitable supports.

(3) The complete fuel bed section weight resting on one load cell, the weight being transmitted through a strong shaft supported inside a frictionless bearing.

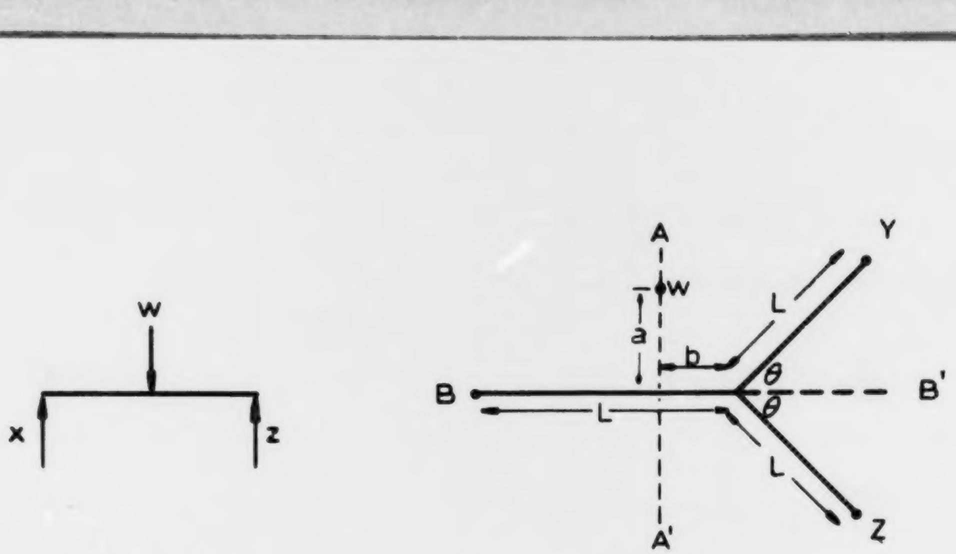
Systems (1) and (3) both give readings of total fuel bed section weight and are not affected by eccentric or shifting loads. In the latter system all moments generated by eccentric loadings are "absorbed" by the bearing and only the vertical components of the weight are transmitted to the load cell. System (1) suffers from the disadvantage of requiring three load cells, thereby increasing costs and errors in measurement threefold. System (2) also proves unsatisfactory because of the errors associated with any shifts in the center of gravity of the systems being weighed; otherwise the system is satisfactory as it has the same inherent load cell error as (3) and eliminates the necessity of a frictionless bearing.

An analysis follows of the error associated with changes in the center of gravity of the system being weighed. The system is represented by Figure C.2.

## TABLE C.I.

## Specifications for BLH Precision C3P1 Load Cell

| | |
|---|---|
| PERFORMANCE | |
| Rated Output (R.O.)-millivolts per volt | 3 |
| Calibration Accuracy - % R.O. | 0.10 |
| Nonlinearity - % R.O. | 0.05 |
| Hysteresis - % R.O. | 0.02 |
| Repeatability - % R.O. | 0.02 |
| Creep - % R.O. | 0.03 |
| ELECTRICAL | |
| Excitation, Recommended | 12 volts, ac or dc |
| maximum | 20 volts, ac or dc |
| Zero Balance - % R.O. | ± 1% |
| Terminal resistance, input-ohms | 350 ± 3.5 |
| output-ohms | 350 ± 5.0 |
| Electrical connection | 10 ft cable |
| Number of bridges | one |
| Insulation resistance-bridge to ground | 5000 megohms |
| shield to ground | 2000 megohms |
| TEMPERATURE | |
| Temperature range, compensated | +15°F to +115°F |
| safe | -30°F to +175°F |
| Temperature effect on rated output | 0.0008% load/°F |
| Temperature effect on zero balance | 0.0015% R.)./°F |
| ADVERSE LOAD RATING | |
| Safe overload - % rated capacity. | 150 |
| Ultimate overload - % rated capacity | 300 |
| Maximum side load without damage - % rated capacity | 10 |
| Maximum bending moment without damage - % in inch-lbs | 25 |
| Maximum torque load without damage - % rated capacity in inch-lbs | 10 |
| Deflection inches | 0.007 |



ELEVATION PLAN

Fig. C.2. Distribution of Forces in Weighing System

By force balance: $W = X + Y + Z$ (C-9)

Moments about Plane AA': $X(L - b) = Y(L \cos\theta + b) + Z(L \cos\theta + b)$ (C-10)

Moments about plane BB': $Wa + ZL \sin\theta = YL \sin$ (C-11)

Solving for X, Y, Z, the forces at the points indicated using (C-10) and (C-11), gives

$$X = \frac{W(\cos\theta + \frac{b}{L})}{\cos\theta + 1} \qquad (C\text{-}12)$$

$$Z = \frac{W}{2}\left[1 - \frac{a}{1 \sin\theta} - \frac{1}{1 + A}\right] \qquad (C\text{-}13)$$

$$Y = W\left[\frac{1}{(1 + A)} - \left\{\frac{1}{2} - \frac{a}{2L \sin\theta} - \frac{1}{2(1 + A)}\right\}\right] \qquad (C\text{-}14)$$

where $A = \dfrac{1 - \frac{b}{L}}{\cos\theta + \frac{b}{L}}$

These results show that the best location for the load cell is at point X as shifts in the center of gravity in the plane AA' do not affect the resulting force at this point. The change in the resulting force at X caused by changes in the load W and movement in the system center of gravity in the plane BB' can be found as follows.

$$\Delta X = \frac{dX}{dW}\,\Delta W + \frac{dX}{db}\,\Delta b \qquad \text{(C-15)}$$

Now from the equation (C-12)

$$\frac{dX}{dW} = \frac{\cos\theta + \frac{b}{L}}{\cos\theta + 1} \qquad \text{(C-16)}$$

and

$$\frac{dX}{db} = \frac{\frac{W}{L}}{\cos\theta + 1} \qquad \text{(C-17)}$$

and substituting these values into equation (C-15) gives

$$\Delta X = \frac{\cos\theta + \frac{b}{L}}{\cos\theta + 1}\,\Delta W + \frac{\frac{W}{L}}{\cos\theta + 1}\,\Delta b \qquad \text{(C-18)}$$

The fractional change in the force at X is then given by

$$\frac{\Delta X}{X} = \frac{\Delta W}{W}\left[1 + \frac{\frac{W}{\Delta W}}{L\cos\theta + b}\,\Delta b\right] \qquad \text{(C-19)}$$

Equation (C-20) shows that for shifts in the center of gravity of the load to have an effect of less than one percent on the measurement of the weight change of the load

$$\frac{\frac{W}{\Delta W}}{L(\cos\theta + \frac{b}{L})}\,\Delta b < 0.01 \qquad \text{(C-20)}$$

Equations (C-16) and (C-20) show that to maximize the sensitivity of the weighing system and to minimize errors caused by shifts in the center of gravity of the applied load, b should be as close to X as possible.

The required length L for equation (C-20) to be satisfied can now be calculated. Consideration of the geometry of the fuel bed section suggests that $\Delta b$ could be of the order of 0.01 ft. It should be noted that $\Delta b$ represents a movement of the center of gravity caused both by shifts in the burning fuel bed and/or by a gross shift of the center of gravity of the fuel bed section. The dead weight of the fuel bed section is around 1000 pounds and the load cell is capable of detecting one tenth of 1 percent of this weight; therefore, $\frac{W}{\Delta W}$ will be about 1000. A reasonable value of $\cos\theta + \frac{b}{L}$ would be approximately unity.

Putting these values into equation (C-20) shows that L would need to be greater than 1000 ft for the weighing system to perform adequately.

System (3) was, therefore, chosen as being the best available, subject to the limitations imposed by the "frictionless bearing." This limitation was overcome by using linear ball bushings which have relatively little drag. The minimum drag condition is also helped by the very small load cell deflections, which are of the order of 0.008 inch per 1000 pounds.

Calibration of the Weighing System. The calibration of the weighing system was performed in three parts: (1) calibration of the load cell alone; (2) calibration of the complete weighing system with fuel bed section in place but not connected to the flexible diaphragm; (3) calibration of the complete weighing system with flexible diaphragm attached. These tests were done to determine the individual errors associated with the drag of the ball bushing and the flexible diaphragm.

The calibration of the load cell was performed in an apparatus shown schematically in Figure C.3. The millivolt (mv) output of the load cell per volt (V) input was measured for different loadings at position W. The change in mv/V output $(\Delta\frac{mv}{v})$ was noted for each ΔW increment or, more correctly, $\frac{\Delta W\cdot b}{a}$ increment The slope of the calibration curve, which is the plot of $\frac{mv}{V}$ as a function of weight, was found at each point by computing the ratio $\frac{mv}{V}/\frac{\Delta W\cdot b}{a}$. These values showed

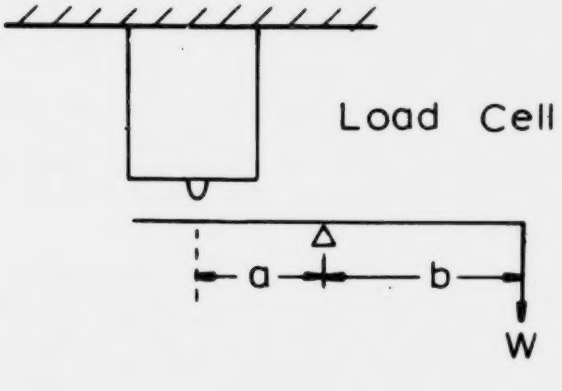


Fig. C.3. Schematic of Apparatus for Load Cell Calibration

no trends over the range of weights studied from 0 through 1000 pounds. The average values was found to be:

Slope of calibration curve = $0.003007 \pm 0.000006 \frac{mv}{Vlb}$ mV $V^{-1}$ $lb^{-1}$

which compares favorably with the manufacturer's data which quotes

Slope of calibration curve = $0.003001 \pm 0.000003 \frac{mv}{Vlb}$ mV $V^{-1}$ $lb^{-1}$

The next two calibrations were performed with the load cell in situ in the apparatus and under the conditions outlined above. For test (2) weights of known tare were added and subtracted from the fuel bed support plate; for test (3) weights totaling approximately 130 pounds were added to the fuel bed support plate and then removed in roughly 1/2-pounds increments. In both tests the input and output voltages of the load cell were recorded on the Data Acquisition System.

The data obtained in these two tests were tested in two ways: (1) The slope of the calibration curve obtained in the first test was used to calculate the new weight added to the fuel bed support plate and the value obtained compared to the actual weight; (2) The data was subjected to a test which computed the best straight line through a plot of $\frac{mv}{V}$ versus the weight on the fuel bed section support plate. These results are shown in the Tables C.II and C.III located at the end of this appendix.

The nomenclature used in the tables is given below:

Standard error of mean = $\frac{\sigma}{\sqrt{N}} \quad 1 \pm \frac{1}{\sqrt{2\ (N - 1)}}$

N = number of data points
$\sigma$ = standard deviation of data
$E = \frac{1}{\sqrt{2\ (N - 1)}}$
m = slope of calibration curve (V $V^{-1}$ $lb^{-1}$)
V/V = voltage output of load cell per volt input
$V/V_o$ = voltage output of load cell per volt input when loaded with the dead weight of the Fuel Bed Section

Discussion of Results. The data from the test with the diaphragm disconnected showed minimal drag caused by the ball bushing. This is indicated by the very small (± 1 to 1-1/2 percent) change in calibration slopes obtained from the best fit of the data. The calibration slopes obtained from the two tests were different and their shifts were in the directions expected, the slope being greater than the standard calibration curve in the test where weights were being subtracted, and vice versa.

The test with the diaphragm connected showed the presence of some drag associated with the diaphragm seal and the mechanism employed to join the two sections of the apparatus together. The effect was particularly noticeable under small load conditions. Subsequent changes to the joining mechanism have helped reduce these errors to within acceptable limits.

## Table C.II (a)

### Load Cell Test 1: Diaphragm Disconnected; Weights Added.
### (Least Squares Fit to Data)

```
                    POLYNOMIAL EXPRESSION WITH M = 18 DATA POINTS


                    WEIGHT LBS      V/V          STD ERROR OF MEAN        E
                                                      IN LBS

                      10.450     0.00277538         4.466830         0.213200
                      20.500     0.00282126         0.227223         0.223606
                      30.000     0.00285112         0.622044         0.213200
                      40.500     0.00288119         0.386241         0.213200
                      50.650     0.00291300         0.349353         0.123091
                      63.500     0.00295012         0.415984         0.188982
                      73.650     0.00298127         0.295312         0.204124
                      84.100     0.00301298         0.310807         0.196116
                      93.600     0.00304130         0.215107         0.162221
                     103.650     0.00307098         0.393316         0.188982
                     113.800     0.00310184         0.139754         0.162221
                     124.300     0.00313422         0.251087         0.158113
                     129.400     0.00315003         0.247636         0.196116
                     130.600     0.00315272         0.403757         0.182574
                     132.800     0.00315731         0.311162         0.213200
                     133.300     0.00315863         0.178543         0.196116
                     133.800     0.00316081         0.250686         0.162221
                     134.900     0.00316460         0.199800         0.154303

          DET =0.32530495E-05
STD DEVIATION IN THE CURVE FIT =   0.366089E-05   THE Y INTERCEPT  OF THE STRAIGHT LINE IS   0.148445E-06
  THE SLOPE OF THE STRAIGHT LINE IS   0.303748E-05
```

## Table C.II (b)

### Load Cell Test 1: Diaphragm Disconnected; Weights Added.
(Comparison of calculated and actual weights using least squares calibration, $m = 0.303748 \times 10^{-5}\ V\ V^{-1}\ lb^{-1}$)

| V/V — V/VO | ACTUAL WEIGHT | STD.ERROR OF MEAN IN LBS | E | CALCULATED WEIGHT | PERCENT-ERROR |
|---|---|---|---|---|---|
| 0.0000195199 | 10.450 | 4.466830 | 0.213200 | 6.377 | 38.971323 |
| 0.0000653999 | 20.500 | 0.227223 | 0.223606 | 21.482 | 4.790711 |
| 0.0000952600 | 30.000 | 0.622044 | 0.213200 | 31.312 | 4.375318 |
| 0.0001253299 | 40.500 | 0.386241 | 0.213200 | 41.212 | 1.758595 |
| 0.0001571399 | 50.650 | 0.349353 | 0.123091 | 51.684 | 2.042860 |
| 0.0001942599 | 63.500 | 0.415984 | 0.188982 | 63.905 | 0.638336 |
| 0.0002254100 | 73.650 | 0.295312 | 0.204124 | 74.160 | 0.693193 |
| 0.0002571200 | 84.100 | 0.310807 | 0.196116 | 84.600 | 0.594640 |
| 0.0002854399 | 93.600 | 0.215107 | 0.162221 | 93.923 | 0.345720 |
| 0.0003151200 | 103.650 | 0.393316 | 0.188982 | 103.694 | 0.043255 |
| 0.0003459799 | 113.800 | 0.139754 | 0.162221 | 113.854 | 0.047938 |
| 0.0003783600 | 124.300 | 0.251087 | 0.158113 | 124.514 | 0.172716 |
| 0.0003941700 | 129.400 | 0.247636 | 0.196116 | 129.719 | 0.247024 |
| 0.0003968599 | 130.600 | 0.403757 | 0.182574 | 130.605 | 0.004020 |
| 0.0004014499 | 132.800 | 0.311162 | 0.213200 | 132.116 | -0.514782 |
| 0.0004027700 | 133.300 | 0.178543 | 0.196116 | 132.550 | -0.561936 |
| 0.0004049500 | 133.800 | 0.250686 | 0.162221 | 133.268 | -0.397131 |
| 0.0004087399 | 134.900 | 0.199800 | 0.154303 | 134.516 | -0.284373 |

## Table C.II (c)

**Load Cell Test 1: Diaphragm Disconnected; Weights Added.**

(Comparison of calculated and actual weights using calibration curve obtained from test on load cell alone)

SLOPE = .000003003, Y INTERCEPT = 0

| V/V - V/VO | ACTUAL WEIGHT | STD ERROR OF MEAN IN LBS | E | CALCULATED WEIGHT | PERCENT ERROR |
|---|---|---|---|---|---|
| 0.0000195199 | 10.450 | 4.466830 | 0.213200 | 6.500 | -37.797452 |
| 0.0000653999 | 20.500 | 0.227223 | 0.223606 | 21.778 | 6.235227 |
| 0.0000952600 | 30.000 | 0.622044 | 0.213200 | 31.721 | 5.738706 |
| 0.0001253299 | 40.500 | 0.386241 | 0.213200 | 41.734 | 3.049213 |
| 0.0001571399 | 50.650 | 0.349353 | 0.123091 | 52.327 | 3.312284 |
| 0.0001942599 | 63.500 | 0.415984 | 0.188982 | 64.688 | 1.871880 |
| 0.0002254100 | 73.650 | 0.295312 | 0.204124 | 75.061 | 1.916639 |
| 0.0002571200 | 84.100 | 0.310807 | 0.196116 | 85.621 | 1.808615 |
| 0.0002854399 | 93.600 | 0.215107 | 0.162221 | 95.051 | 1.550670 |
| 0.0003151200 | 103.650 | 0.393316 | 0.188982 | 104.935 | 1.239811 |
| 0.0003459799 | 113.800 | 0.139754 | 0.162221 | 115.211 | 1.240294 |
| 0.0003783600 | 124.300 | 0.251087 | 0.158113 | 125.994 | 1.362836 |
| 0.0003941700 | 129.400 | 0.247636 | 0.196116 | 131.258 | 1.436430 |
| 0.0003968599 | 130.600 | 0.403757 | 0.182574 | 132.154 | 1.190284 |
| 0.0004014499 | 132.800 | 0.311162 | 0.213200 | 133.682 | 0.664897 |
| 0.0004027700 | 133.300 | 0.178543 | 0.196116 | 134.122 | 0.617062 |
| 0.0004049500 | 133.800 | 0.250686 | 0.162221 | 134.648 | 0.783621 |
| 0.0004087399 | 134.900 | 0.199800 | 0.154303 | 136.110 | 0.897372 |

## Table C.III (a)

## Load Cell Test 2: Diaphragm Disconnected; Weights Subtracted. (Least Squares Fit to Data)

POLYNOMIAL EXPRESSION WITH M = 109 DATA POINTS

| WEIGHT LBS | V/V | STD ERROR OF MEAN IN LBS | E |
|---|---|---|---|
| 0.000 | 0.00276187 | 0.087959 | 0.267261 |
| 134.350 | 0.00316061 | 0.046598 | 0.267261 |
| 133.800 | 0.00315840 | 0.154134 | 0.353553 |
| 133.300 | 0.00315684 | 0.060388 | 0.288675 |
| 132.800 | 0.00315479 | 0.038809 | 0.288675 |
| 131.600 | 0.00315175 | 0.060984 | 0.267261 |
| 130.400 | 0.00314754 | 0.035331 | 0.250000 |
| 125.300 | 0.00313243 | 0.061547 | 0.213200 |
| 120.250 | 0.00311715 | 0.117387 | 0.223606 |
| 117.650 | 0.00310932 | 0.103234 | 0.223606 |
| 115.150 | 0.00310229 | 0.034699 | 0.097128 |
| 114.250 | 0.00310092 | 0.075210 | 0.171498 |
| 113.700 | 0.00309922 | 0.078477 | 0.250000 |
| 113.150 | 0.00309688 | 0.123908 | 0.250000 |
| 112.650 | 0.00309508 | 0.092871 | 0.223606 |
| 112.150 | 0.00309318 | 0.167927 | 0.267261 |
| 110.950 | 0.00308965 | 0.125806 | 0.223606 |
| 109.750 | 0.00308594 | 0.114953 | 0.250000 |
| 107.250 | 0.00307857 | 0.087967 | 0.250000 |
| 104.650 | 0.00307062 | 0.114458 | 0.267261 |
| | | | |
| 104.200 | 0.00307054 | 0.061819 | 0.204124 |
| 103.700 | 0.00306871 | 0.088113 | 0.250000 |
| 103.200 | 0.00306724 | 0.087082 | 0.223606 |
| 102.650 | 0.00306610 | 0.228355 | 0.235702 |
| 102.100 | 0.00306340 | 0.086200 | 0.223606 |
| 100.900 | 0.00306046 | 0.130082 | 0.267261 |
| 99.700 | 0.00305502 | 0.211143 | 0.250000 |
| 97.100 | 0.00304834 | 0.083911 | 0.250000 |
| 94.600 | 0.00304067 | 0.148201 | 0.250000 |
| 94.700 | 0.00304181 | 0.094498 | 0.250000 |
| 94.150 | 0.00304088 | 0.137293 | 0.250000 |
| 93.600 | 0.00303894 | 0.099576 | 0.250000 |
| 93.100 | 0.00303694 | 0.148042 | 0.267261 |
| 92.600 | 0.00303469 | 0.081137 | 0.250000 |
| 91.400 | 0.00303110 | 0.065101 | 0.158113 |
| 90.200 | 0.00302742 | 0.081893 | 0.267261 |
| 87.700 | 0.00302053 | 0.087431 | 0.267261 |
| 85.100 | 0.00301226 | 0.075879 | 0.250000 |
| 83.250 | 0.00301161 | 0.100327 | 0.158113 |
| 82.750 | 0.00300954 | 0.117997 | 0.267261 |
| | | | |
| 82.250 | 0.00300745 | 0.052210 | 0.158113 |
| 81.700 | 0.00300565 | 0.116945 | 0.250000 |
| 81.150 | 0.00300396 | 0.096478 | 0.250000 |
| 79.950 | 0.00299975 | 0.144525 | 0.250000 |
| 78.750 | 0.00299631 | 0.111604 | 0.250000 |
| 76.150 | 0.00298806 | 0.175289 | 0.250000 |
| 73.650 | 0.00298143 | 0.083249 | 0.235702 |
| 73.150 | 0.00298046 | 0.065803 | 0.158113 |

```
           WEIGHT LBS      V/V        STD ERROR OF MEAN          E
                                          IN LBS

             72.500     0.00297969       0.088225        0.158113
             72.050     0.00297879       0.077657        0.250000
             71.550     0.00297462       0.129134        0.250000
             71.350     0.00297373       0.167166        0.250000
             69.850     0.00296936       0.121627        0.250000
             68.650     0.00296550       0.173437        0.250000
             66.150     0.00295796       0.105787        0.250000
             63.550     0.00295014       0.129169        0.171498
             59.900     0.00294147       0.092825        0.158113
             59.400     0.00293967       0.126820        0.250000
             58.900     0.00293836       0.091526        0.158113
             58.350     0.00293679       0.097937        0.250000

             57.900     0.00293652       0.070160        0.250000
             56.600     0.00293095       0.114572        0.250000
             55.400     0.00292722       0.064757        0.250000
             52.900     0.00291936       0.045559        0.250000
             50.300     0.00291186       0.070424        0.166666
             49.750     0.00291093       0.135835        0.250000
             49.200     0.00290969       0.093346        0.250000
             48.650     0.00290867       0.094916        0.250000
             48.150     0.00290552       0.109226        0.250000
             47.650     0.00290431       0.175941        0.250000
             46.450     0.00290029       0.105059        0.250000
             45.250     0.00289662       0.113492        0.250000
             42.750     0.00288937       0.105953        0.250000
             40.150     0.00288136       0.148885        0.250000
             39.600     0.00288185       0.553602        0.250000
             39.100     0.00287906       0.452496        0.250000
             38.600     0.00287677       0.559208        0.250000
             38.350     0.00287638       0.648764        0.250000
             37.500     0.00287309       0.173272        0.250000
             36.300     0.00286956       0.070079        0.250000

             35.100     0.00296605       0.070172        0.250000
             32.500     0.00295845       0.063325        0.133630
             30.000     0.00295091       0.108962        0.250000
             29.550     0.00295100       0.058408        0.136082
             29.050     0.00294925       0.075873        0.250000
             28.550     0.00294763       0.144236        0.250000
             28.000     0.00294521       0.137972        0.250000
             27.450     0.00294347       0.172086        0.250000
             26.250     0.00294024       0.176008        0.250000
             25.050     0.00293592       0.069291        0.250000
             22.450     0.00292842       0.073341        0.158113
             19.850     0.00292172       0.104325        0.136082
             20.050     0.00292215       0.188517        0.235702
             19.500     0.00291952       0.117575        0.162221
             18.950     0.00291941       0.191180        0.158113
             17.950     0.00291679       0.152593        0.250000
             16.750     0.00281160       0.161448        0.250000
             15.550     0.00280791       0.097793        0.250000
             12.950     0.00279919       0.110664        0.250000
             10.450     0.00279150       0.152702        0.250000

              9.600     0.00279145       0.112248        0.250000
              9.100     0.00278934       0.198373        0.250000
              8.600     0.00278901       0.274060        0.250000
              8.050     0.00278460       0.346896        0.250000
              7.500     0.00278385       0.191493        0.250000
              6.300     0.00278356       0.169981        0.250000

              5.100     0.00277591       0.152067        0.250000
              2.600     0.00276867       0.099768        0.213200
            134.900     0.00316196       0.042383        0.250000

      DET =0.15878655E 06
STD DEVIATION IN THE CURVE FIT =   0.108762E-05   THE Y INTERCEPT  OF THE STRAIGHT LINE IS   0.679259E-05
  THE SLOPE OF THE STRAIGHT LINE IS   0.295554E-05
```

## Table C.III (b)

**Load Cell Test 2: Diaphragm Disconnected; Weights Subtracted.**

(Comparison of calculated and actual weights using least squares calibration, m = 0.295554 X $10^{-5}$ V $V^{-1}$ $lb^{-1}$)

| V/V - V/VO | ACTUAL WEIGHT | STD ERROR OF MEAN IN LBS | E | CALCULATED WEIGHT | PERCENT ERROR |
|---|---|---|---|---|---|
| 0.0000060099 | 0.000 | 0.087959 | 0.267261 | -0.264 | -26.478730 |
| 0.0004047499 | 134.350 | 0.046598 | 0.267261 | 134.647 | 0.221483 |
| 0.0004025399 | 133.800 | 0.154134 | 0.353553 | 133.899 | 0.074601 |
| 0.0004009799 | 133.300 | 0.060388 | 0.288675 | 133.371 | 0.054010 |
| 0.0003989300 | 132.800 | 0.038809 | 0.288675 | 132.678 | -0.091576 |
| 0.0003958899 | 131.600 | 0.060984 | 0.267261 | 131.649 | 0.037850 |
| 0.0003916799 | 130.400 | 0.035331 | 0.250000 | 130.225 | -0.133917 |
| 0.0003765700 | 125.300 | 0.061547 | 0.213200 | 125.112 | -0.149278 |
| 0.0003612900 | 120.250 | 0.117387 | 0.223606 | 119.943 | -0.255287 |
| 0.0003534600 | 117.650 | 0.103234 | 0.223606 | 117.293 | -0.302794 |
| 0.0003464299 | 115.150 | 0.034699 | 0.097128 | 114.975 | -0.203920 |
| 0.0003450599 | 114.250 | 0.075210 | 0.171498 | 114.451 | 0.176499 |
| 0.0003433599 | 113.700 | 0.078477 | 0.250000 | 113.876 | 0.155198 |
| 0.0003410199 | 113.150 | 0.123908 | 0.250000 | 113.084 | -0.057684 |
| 0.0003392199 | 112.650 | 0.092871 | 0.223606 | 112.475 | -0.154721 |
| 0.0003373199 | 112.150 | 0.167927 | 0.267261 | 111.832 | -0.282793 |
| 0.0003337900 | 110.950 | 0.125806 | 0.223606 | 110.638 | -0.280771 |
| 0.0003300800 | 109.750 | 0.114953 | 0.250000 | 109.383 | -0.334198 |
| 0.0003227099 | 107.250 | 0.087967 | 0.250000 | 106.889 | -0.336035 |
| 0.0003147600 | 104.650 | 0.114458 | 0.267261 | 104.199 | -0.430246 |
| 0.0003146799 | 104.200 | 0.061819 | 0.204124 | 104.172 | -0.026220 |
| 0.0003128499 | 103.700 | 0.088113 | 0.250000 | 103.553 | -0.141269 |
| 0.0003113799 | 103.200 | 0.087082 | 0.223606 | 103.056 | -0.139404 |
| 0.0003102399 | 102.650 | 0.228355 | 0.235702 | 102.670 | 0.019892 |
| 0.0003075400 | 102.100 | 0.086200 | 0.223606 | 101.756 | -0.336058 |
| 0.0003046000 | 100.900 | 0.130032 | 0.267261 | 100.762 | -0.136625 |
| 0.0002991599 | 99.700 | 0.211143 | 0.250000 | 98.921 | -0.780803 |
| 0.0002924799 | 97.100 | 0.083911 | 0.250000 | 96.661 | -0.451717 |
| 0.0002848099 | 94.500 | 0.148201 | 0.250000 | 94.066 | -0.564203 |
| 0.0002859500 | 94.700 | 0.094498 | 0.250000 | 94.451 | -0.261901 |
| 0.0002850200 | 94.150 | 0.137293 | 0.250000 | 94.137 | -0.013471 |
| 0.0002830900 | 93.600 | 0.099576 | 0.250000 | 93.480 | -0.127217 |
| 0.0002810600 | 93.100 | 0.148042 | 0.267261 | 92.804 | -0.317689 |
| 0.0002788299 | 92.600 | 0.081137 | 0.250000 | 92.042 | -0.601565 |
| 0.0002752399 | 91.400 | 0.065101 | 0.158113 | 90.828 | -0.625507 |
| 0.0002715600 | 90.200 | 0.081893 | 0.267261 | 89.583 | -0.683846 |
| 0.0002646699 | 87.700 | 0.087431 | 0.267261 | 87.251 | -0.510875 |
| 0.0002563999 | 85.100 | 0.075879 | 0.250000 | 84.453 | -0.759301 |
| 0.0002557499 | 83.250 | 0.100327 | 0.158113 | 84.233 | 1.181873 |
| 0.0002536800 | 82.750 | 0.117997 | 0.267261 | 83.533 | 0.946866 |
| 0.0002515999 | 82.250 | 0.052210 | 0.158113 | 82.826 | 0.700775 |
| 0.0002497900 | 81.700 | 0.116945 | 0.250000 | 82.217 | 0.633248 |
| 0.0002480999 | 81.150 | 0.096478 | 0.250000 | 81.645 | 0.610668 |
| 0.0002438999 | 79.950 | 0.144525 | 0.250000 | 80.221 | 0.339109 |
| 0.0002404499 | 78.750 | 0.111604 | 0.250000 | 79.057 | 0.390102 |
| 0.0002322000 | 76.150 | 0.175289 | 0.250000 | 76.265 | 0.152128 |
| 0.0002255700 | 73.650 | 0.083249 | 0.235702 | 74.022 | 0.505916 |
| 0.0002246000 | 73.150 | 0.065803 | 0.158113 | 73.694 | 0.744239 |
| 0.0002228199 | 72.600 | 0.088225 | 0.158113 | 73.092 | 0.677897 |
| 0.0002209199 | 72.050 | 0.077657 | 0.250000 | 72.449 | 0.554191 |
| 0.0002187600 | 71.550 | 0.109134 | 0.250000 | 71.718 | 0.235453 |
| 0.0002178699 | 71.050 | 0.162166 | 0.250000 | 71.417 | 0.517013 |
| 0.0002134999 | 69.850 | 0.121627 | 0.250000 | 69.938 | 0.127076 |
| 0.0002096400 | 68.650 | 0.173437 | 0.250000 | 68.632 | -0.025134 |
| 0.0002021000 | 66.150 | 0.105787 | 0.250000 | 66.081 | -0.103384 |
| 0.0001942799 | 63.550 | 0.129169 | 0.171498 | 63.435 | -0.179795 |

```
-V/V- - V/VO       ACTUAL WEIGHT     STD ERROR OF     E          CALCULATED WEIGHT    PERCENT ERROR
                                     MEAN IN LBS

0.0001856099          59.900          0.092825     0.158113          60.502              1.005466
0.0001938099          59.400          0.104820     0.250000          59.893              0.830387
0.0001924900          58.900          0.091524     0.158113          59.443              0.922325
0.0001909299          58.350          0.097937     0.250000          58.918              0.974327
0.0001787599          57.800          0.070160     0.250000          58.184              0.665397
0.0001749900          56.600          0.114572     0.250000          56.909              0.545994
0.0001713599          55.400          0.064287     0.250000          55.680              0.506921
0.0001634799          52.800          0.045559     0.250000          53.014              0.406557
0.0001560000          50.300          0.070424     0.166666          50.483              0.365466
0.0001550700          49.750          0.135835     0.250000          50.169              0.842547
0.0001538300          49.200          0.093346     0.250000          49.749              1.117108
0.0001528100          48.650          0.094916     0.250000          49.404              1.550881
0.0001496599          48.150          0.109226     0.250000          48.338              0.391924
0.0001484499          47.650          0.175841     0.250000          47.929              0.586174
0.0001444299          46.450          0.105059     0.250000          46.569              0.256530
0.0001407599          45.250          0.113492     0.250000          45.327              0.171107
0.0001335099          42.750          0.109950     0.250000          42.874              0.291023
0.0001254999          40.150          0.148885     0.250000          40.164              0.035506
0.0001259900          39.600          0.553602     0.250000          40.330              1.843550
0.0001231999          39.100          0.452496     0.250000          39.386              0.731608
0.0001209099          38.600          0.559208     0.250000          38.611              0.029131
0.0001205199          38.050          0.648764     0.250000          38.479              1.128224
0.0001172299          37.500          0.123272     0.250000          37.366             -0.356988
0.0001140000          36.300          0.070079     0.250000          36.273             -0.073637
0.0001101999          35.100          0.070172     0.250000          34.987             -0.320365
0.0001025900          32.500          0.063325     0.133630          32.412             -0.268510
0.0000950499          30.000          0.108962     0.250000          29.861             -0.461332
0.0000951399          29.550          0.088408     0.136082          29.892              1.157534
0.0000933899          29.050          0.075973     0.250000          29.299              0.860394
0.0000917700          28.550          0.144236     0.250000          28.751              0.706911
0.0000891500          28.000          0.137972     0.250000          27.865             -0.480874
0.0000876100          27.450          0.172084     0.250000          27.344             -0.385059
0.0000843799          26.250          0.176008     0.250000          26.251              0.005489
0.0000800599          25.050          0.069291     0.250000          24.789             -1.038788
0.0000725600          22.450          0.073341     0.158113          22.252             -0.881141
0.0000648599          19.850          0.104325     0.136082          19.646             -1.023101
0.0000662900          20.050          0.188517     0.235702          20.130              0.402743
0.0000636400          19.500          0.117575     0.162221          19.234             -1.363428
0.0000625499          18.950          0.191180     0.158113          18.865             -0.446789
0.0000589299          17.950          0.152593     0.250000          17.640             -1.724130
0.0000557399          16.750          0.161448     0.250000          16.561             -1.127207
0.0000520499          15.550          0.097793     0.250000          15.312             -1.526086
0.0000433299          12.950          0.110664     0.250000          12.362             -4.538143
0.0000356399          10.450          0.152702     0.250000           9.760             -6.598807
0.0000355899           9.600          0.112248     0.250000           9.743              1.494866
0.0000334799           9.100          0.198373     0.250000           9.029             -0.773675
0.0000321499           8.600          0.224060     0.250000           8.579             -0.237271
0.0000287399           8.050          0.346896     0.250000           7.425             -7.753631
0.0000279899           7.500          0.191493     0.250000           7.172             -4.372365
0.0000246799           6.300          0.169981     0.250000           6.052             -3.934206
0.0000200499           5.100          0.152067     0.250000           4.485            -12.047056
0.0000128100           2.600          0.099768     0.213200           2.035            -21.693449
0.0004061000         134.900          0.042383     0.250000         135.104              0.151468
```

## Table C.III (c)

**Load Cell Test 2: Diaphragm Disconnected; Weights Subtracted. (Comparison of calculated and actual weights using calibration curve obtained from test on load cell alone)**

```
SLOPE = .000003003, Y INTERCEPT = 0


V/V - V/VO       ACTUAL WEIGHT    STD ERROR OF       E        CALCULATED WEIGHT   PERCENT ERROR
                                  MEAN IN LBS


 0.0000060399         0.000        0.087959       0.267261          2.001          200.133173
-0.0004047499       134.350        0.046598       0.267261        134.781            0.321462
 0.0004025399       133.800        0.154134       0.353553        134.045            0.183821
 0.0004009799       133.300        0.060388       0.288675        133.526            0.169897
 0.0003989300       132.800        0.038809       0.288675        132.843            0.032999
 0.0003956899       131.600        0.060984       0.267261        131.831            0.175913
 0.0003916799       130.400        0.035331       0.250000        130.429            0.022676
 0.0003765700       125.300        0.061547       0.213203        125.397            0.078160
 0.0003612900       120.250        0.117387       0.223606        120.309            0.049638
 0.0003534600       117.650        0.103234       0.223606        117.702            0.044451
 0.0003464299       115.150        0.034699       0.097128        115.361            0.183504
 0.0003450599       114.250        0.075210       0.171498        114.905            0.573387
 0.0003433599       113.700        0.078477       0.250000        114.338            0.562000
 0.0003410199       113.150        0.123908       0.250000        113.559            0.362150
 0.0003392199       112.650        0.092871       0.223606        112.960            0.275519
 0.0003372199       112.150        0.167927       0.267261        112.327            0.158423
 0.0003337900       110.950        0.125806       0.223606        111.152            0.182227
 0.0003300800       109.750        0.114953       0.250000        109.916            0.151936
 0.0003227099       107.250        0.087967       0.250000        107.462            0.198169
 0.0003147600       104.650        0.114458       0.267261        104.815            0.157845
 0.0003146799       104.200        0.061819       0.204124        104.788            0.564822
 0.0003128499       103.700        0.088113       0.250000        104.179            0.462057
 0.0003113799       103.200        0.087082       0.223606        103.689            0.474460
 0.0003102399       102.650        0.228355       0.235702        103.310            0.642983
 0.0003075400       102.100        0.086200       0.223606        102.410            0.304527
 0.0003046000       100.900        0.130022       0.267261        101.431            0.527157
 0.0002991599        99.700        0.211143       0.250000         99.620           -0.079860
 0.0002924799        97.100        0.083911       0.250000         97.395            0.304775
 0.0002848099        94.600        0.148701       0.250000         94.841            0.255628
 0.0002859500        94.700        0.094498       0.250000         95.221            0.550648
 0.0002850200        94.150        0.137293       0.250000         94.911            0.809086
 0.0002830800        93.600        0.099576       0.250000         94.265            0.711254
 0.0002810800        93.100        0.148042       0.267261         93.599            0.536770
 0.0002788299        92.600        0.081137       0.250000         92.850            0.270499
 0.0002752399        91.400        0.055101       0.158113         91.655            0.279006
 0.0002715600        90.200        0.081893       0.267261         90.429            0.254512
 0.0002646699        87.700        0.087431       0.267261         88.135            0.496234
 0.0002563999        85.100        0.075879       0.250000         85.381            0.330534
 0.0002557499        83.250        0.100327       0.158113         85.164            2.300102
 0.0002536800        82.750        0.117997       0.267261         84.475            2.085226
 0.0002515899        82.250        0.052210       0.158113         83.779            1.859639
 0.0002497900        81.700        0.116945       0.250000         83.180            1.811693
 0.0002480999        81.150        0.096478       0.250000         82.617            1.808234
 0.0002438899        79.950        0.144525       0.250000         81.215            1.582802
 0.0002404499        78.750        0.111604       0.250000         80.069            1.676101
 0.0002327000        76.150        0.175289       0.250000         77.322            1.539957
 0.0002255700        73.650        0.083249       0.235702         75.114            1.988981
 0.0002246000        73.150        0.065803       0.158113         74.791            2.244531
 0.0002228199        72.600        0.088225       0.158113         74.199            2.202663
 0.0002209199        72.050        0.077657       0.250000         73.566            2.104695
 0.0002187600        71.550        0.109134       0.250000         72.847            1.812932
 0.0002178699        71.050        0.162166       0.250000         72.550            2.112290
```

| V/V - V/VO | ACTUAL WEIGHT | STD ERROR OF MEAN IN LBS | E | CALCULATED WEIGHT | PERCENT ERROR |
|---|---|---|---|---|---|
| 0.0002134999 | 69.850 | 0.121627 | 0.250000 | 71.095 | 1.783208 |
| 0.0002096400 | 68.650 | 0.173427 | 0.250000 | 69.810 | 1.690007 |
| 0.0002021000 | 66.150 | 0.105787 | 0.250000 | 67.299 | 1.737516 |
| 0.0001942799 | 63.550 | 0.129169 | 0.171498 | 64.695 | 1.802209 |
| 0.0001856099 | 59.900 | 0.092825 | 0.158113 | 61.808 | 3.185628 |
| 0.0001838099 | 59.400 | 0.104820 | 0.250000 | 61.208 | 3.045102 |
| 0.0001824800 | 58.900 | 0.091524 | 0.158113 | 60.765 | 3.167913 |
| 0.0001809299 | 58.350 | 0.097937 | 0.250000 | 60.249 | 3.255784 |
| 0.0001787599 | 57.800 | 0.070160 | 0.250000 | 59.527 | 2.988130 |
| 0.0001749900 | 56.600 | 0.114572 | 0.250000 | 58.271 | 2.953583 |
| 0.0001713599 | 55.400 | 0.064287 | 0.250000 | 57.062 | 3.001691 |
| 0.0001634799 | 52.800 | 0.045559 | 0.250000 | 54.438 | 3.103966 |
| 0.0001560600 | 50.300 | 0.070424 | 0.166566 | 51.968 | 3.276445 |
| 0.0001550700 | 49.750 | 0.135835 | 0.250000 | 51.638 | 3.795701 |
| 0.0001538300 | 49.200 | 0.093346 | 0.250000 | 51.225 | 4.116750 |
| 0.0001528100 | 48.650 | 0.094916 | 0.250000 | 50.885 | 4.595644 |
| 0.0001496599 | 48.150 | 0.109226 | 0.250000 | 49.836 | 3.503281 |
| 0.0001484499 | 47.650 | 0.175941 | 0.250000 | 49.433 | 3.743754 |
| 0.0001444299 | 46.450 | 0.105059 | 0.250000 | 48.095 | 3.541954 |
| 0.0001407599 | 45.250 | 0.113492 | 0.250000 | 46.873 | 3.587020 |
| 0.0001335099 | 42.750 | 0.109950 | 0.250000 | 44.458 | 3.997366 |
| 0.0001254999 | 40.150 | 0.148865 | 0.250000 | 41.791 | 4.088521 |
| 0.0001259900 | 39.600 | 0.553602 | 0.250000 | 41.954 | 5.946242 |
| 0.0001231999 | 39.100 | 0.452496 | 0.250000 | 41.025 | 4.924912 |
| 0.0001209099 | 38.600 | 0.559208 | 0.250000 | 40.263 | 4.308471 |
| 0.0001205199 | 38.050 | 0.448764 | 0.250000 | 40.133 | 5.474900 |
| 0.0001172299 | 37.500 | [illegible]272 | 0.250000 | 39.037 | 4.100343 |
| 0.0001140000 | 36.300 | 0.[illegible]079 | 0.250000 | 37.962 | 4.578617 |
| 0.0001101999 | 35.100 | 0.0[illegible]172 | 0.250000 | 36.696 | 4.548621 |
| 0.0001025900 | 32.500 | 0.063325 | 0.133630 | 34.162 | 5.115397 |
| 0.0000950499 | 30.000 | 0.108962 | 0.250000 | 31.651 | 5.505605 |
| 0.0000951399 | 29.550 | 0.088408 | 0.136092 | 31.681 | 7.213711 |
| 0.0000932899 | 29.050 | 0.075873 | 0.250000 | 31.098 | 7.053014 |
| 0.0000917700 | 28.550 | 0.144236 | 0.250000 | 30.559 | 7.038320 |
| 0.0000891500 | 28.000 | 0.137972 | 0.250000 | 29.686 | 6.024927 |
| 0.0000876100 | 27.450 | 0.172084 | 0.250000 | 29.174 | 6.281090 |
| 0.0000843799 | 26.250 | 0.176008 | 0.250000 | 28.098 | 7.042162 |
| 0.0000800599 | 25.050 | 0.069291 | 0.250000 | 26.660 | 6.427171 |
| 0.0000725600 | 22.450 | 0.073341 | 0.158113 | 24.162 | 7.628081 |
| 0.0000648599 | 19.850 | 0.104325 | 0.136082 | 21.598 | 8.808068 |
| 0.0000662900 | 20.050 | 0.188517 | 0.235702 | 22.074 | 10.097716 |
| 0.0000636400 | 19.500 | 0.117575 | 0.162221 | 21.192 | 8.677647 |
| 0.0000625499 | 18.950 | 0.191180 | 0.158113 | 20.829 | 9.916468 |
| 0.0000589799 | 17.950 | 0.152593 | 0.250000 | 19.623 | 9.324287 |
| 0.0000557399 | 16.750 | 0.161448 | 0.250000 | 18.561 | 10.814558 |
| 0.0000520499 | 15.550 | 0.097793 | 0.250000 | 17.332 | 11.464098 |
| 0.0000433299 | 12.950 | 0.110664 | 0.250000 | 14.428 | 11.420109 |
| 0.0000356399 | 10.450 | 0.152702 | 0.250000 | 11.868 | 13.570638 |
| 0.0000355899 | 9.600 | 0.112248 | 0.250000 | 11.851 | 23.452933 |
| 0.0000334799 | 9.100 | 0.198373 | 0.250000 | 11.148 | 22.514643 |
| 0.0000321499 | 8.600 | 0.224060 | 0.250000 | 10.705 | 24.487912 |
| 0.0000287399 | 8.050 | 0.346896 | 0.250000 | 9.570 | 18.887323 |
| 0.0000279899 | 7.500 | 0.191493 | 0.250000 | 9.320 | 24.275722 |
| 0.0000246799 | 6.300 | 0.169981 | 0.250000 | 8.218 | 30.451554 |
| 0.0000200499 | 5.100 | 0.152067 | 0.250000 | 6.676 | 30.914836 |
| 0.0000128100 | 2.600 | 0.099768 | 0.213200 | 4.265 | 64.066703 |
| 0.0004061000 | 134.900 | 0.042383 | 0.250000 | 135.231 | 0.245689 |

## Table C.IV (a)

## Load Cell Test 3: Diaphragm Connected; Weights Subtracted.
## (Least Squares Fit to Data)

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POLYNOMIAL EXPRESSION WITH M = 101 DATA POINTS


WEIGHT LBS      V/V          STD ERROR OF MEAN          E
                                 IN LBS

  133.900     0.00327691        0.249629          0.235702
  133.350     0.00322599        0.239830          0.204124
  132.800     0.00322360        0.443423          0.235702
  132.300     0.00322188        0.494390          0.267261
  131.800     0.00322141        0.329635          0.250000
  130.600     0.00321639        0.474945          0.235702
  129.400     0.00321373        0.344138          0.250000
  126.900     0.00320559        0.286887          0.235702
  124.300     0.00319849        0.352158          0.235702
  123.750     0.00319826        0.277397          0.196116
  123.200     0.00319650        0.391461          0.250000
  122.650     0.00319496        0.447968          0.235702
  122.150     0.00319070        0.519728          0.250000
  121.650     0.00319031        0.253106          0.235702
  120.450     0.00318660        0.366843          0.235702
  119.250     0.00318405        0.330735          0.235702
  116.750     0.00317427        0.276605          0.235702
  114.150     0.00316834        0.257723          0.250000
  113.250     0.00316708        0.256924          0.196116
  112.700     0.00316679        0.404838          0.235702

  112.150     0.00316026        1.287780          0.235702
  111.650     0.00316061        1.480750          0.250000
  111.150     0.00315954        0.368118          0.182574
  109.950     0.00315449        0.255738          0.250000
  108.750     0.00315183        0.720822          0.408248
  106.250     0.00314629        0.475166          0.250000
  103.650     0.00313813        0.392473          0.250000
  102.800     0.00313663        0.368124          0.250000
  102.250     0.00313543        0.387284          0.250000
  101.700     0.00313216        0.495741          0.235702
  101.200     0.00313019        0.448883          0.267261
  100.700     0.00312945        0.281870          0.204124
   99.500     0.00312533        0.420329          0.250000
   98.300     0.00312077        0.426425          0.250000
   95.800     0.00311473        0.253942          0.188982
   93.200     0.00310760        0.334161          0.250000
   93.300     0.00310816        0.399030          0.235702
   92.750     0.00310566        0.264621          0.250000
   92.200     0.00310440        0.336684          0.267261
   91.700     0.00310508        0.312930          0.235702

   91.200     0.00310214        0.330276          0.188982
   90.000     0.00309944        0.375413          0.250000
   88.800     0.00309270        0.295365          0.250000
   86.300     0.00308717        0.267781          0.250000
   83.700     0.00308032        0.343911          0.235702
   82.600     0.00307858        0.289634          0.150755
   82.050     0.00307654        0.360583          0.250000
   81.550     0.00307357        0.379602          0.250000
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WEIGHT LBS     V/V        STD ERROR OF MEAN          E
                                IN LBS

  79.850    0.00307510        0.264393          0.235702
  78.650    0.00307059        0.290619          0.235702
  76.150    0.00306839        0.287583          0.235702
  73.550    0.00306263        0.264594          0.223606
  73.100    0.00305695        0.474611          0.250000
  72.000    0.00304815        0.316483          0.182574
  71.000    0.00305205        0.273375          0.250000
  69.800    0.00304262        0.343094          0.250000
  68.600    0.00304399        0.374079          0.223606
  66.100    0.00303536        0.260236          0.223606
  63.500    0.00303614        0.654801          0.188982
  59.900    0.00302585        1.218550          0.250000

  58.800    0.00301756        0.625990          0.223606
  57.800    0.00301101        0.236870          0.204124
  56.600    0.00301363        0.274864          0.408248
  55.400    0.00300307        0.830357          0.353553
  52.900    0.00299729        0.280480          0.353553
  50.300    0.00299449        0.237963          0.353553
  49.750    0.00299797        0.560432          0.408248
  48.650    0.00298409        0.109925          0.408248
  47.650    0.00298626        0.512599          0.235702
  46.450    0.00298395        0.296994          0.188982
  45.250    0.00296220        0.412831          0.353553
  42.750    0.00297141        0.708653          0.408248
  40.150    0.00297095        0.466290          0.353553
  39.600    0.00296103        0.566014          0.353553
  38.500    0.00295648        0.636892          0.353553
  37.900    0.00294805        0.374270          0.250000
  36.300    0.00293773        0.390510          0.353553
  35.100    0.00294458        0.486590          0.353553
  32.600    0.00294496        0.445228          0.408248
  30.000    0.00294246        0.517740          0.353553

  29.150    0.00293790        0.289448          0.353553
  28.050    0.00292328        0.434817          0.353553
  27.050    0.00292029        0.393662          0.235702
  25.850    0.00291374        0.607149          0.408248
  24.650    0.00290737        0.696990          0.408248
  22.150    0.00290332        0.641565          0.408248
  19.950    0.00290022        0.584725          0.408248
  19.100    0.00289193        0.471173          0.316227
  18.000    0.00288555        0.700770          0.408248
  17.000    0.00287929        0.704803          0.316227
  15.800    0.00287912        0.523494          0.250000
  14.600    0.00288061        0.300282          0.353553
  12.100    0.00286359        0.509966          0.353553
   9.500    0.00286108        0.612154          0.353553
   9.600    0.00286107        0.432774          0.250000
   8.500    0.00286308        0.570890          0.353553
   7.500    0.00285552        0.795925          0.353553
   6.300    0.00284497        0.343686          0.408249
   5.100    0.00284984        0.646477          0.353553
   2.600    0.00283814        0.591646          0.223606

   0.000    0.00283083        0.586830          0.250000

       DET =0.16068364E 06
STD DEVIATION IN THE CURVE FIT =   0.573595E-05   THE Y INTERCEPT  OF THE STRAIGHT LINE IS   0.964619E-05
  THE SLOPE OF THE STRAIGHT LINE IS   0.289077E-05
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## Table C.IV (b)

**Load Cell Test 3: Diaphragm Connected; Weights Subtracted.**

**(Comparison of calculated and actual weights using least squares calibration, $m = 0.289077 \times 10^{-5}\ V\ V^{-1}\ lb^{-1}$)**

| V/V - V/VO | ACTUAL WEIGHT | STD ERROR OF MEAN IN LBS | E | CALCULATED WEIGHT | PERCENT ERROR |
|---|---|---|---|---|---|
| 0.0003960800 | 133.900 | 0.249629 | 0.235702 | 133.678 | -0.165488 |
| 0.0003951600 | 133.350 | 0.239830 | 0.204124 | 133.360 | 0.007616 |
| 0.0003927700 | 132.800 | 0.443423 | 0.235702 | 132.533 | -0.200762 |
| 0.0003910500 | 132.300 | 0.494390 | 0.267261 | 131.938 | -0.273324 |
| 0.0003905800 | 131.800 | 0.329635 | 0.250000 | 131.775 | -0.018357 |
| 0.0003855600 | 130.600 | 0.474945 | 0.235702 | 130.039 | -0.429361 |
| 0.0003829000 | 129.400 | 0.344138 | 0.250000 | 129.119 | -0.217093 |
| 0.0003747600 | 126.900 | 0.286887 | 0.235702 | 126.303 | -0.470277 |
| 0.0003676600 | 124.300 | 0.352158 | 0.235702 | 123.847 | -0.364338 |
| 0.0003674300 | 123.750 | 0.277397 | 0.196116 | 123.767 | 0.014192 |
| 0.0003656700 | 123.200 | 0.391461 | 0.250000 | 123.158 | -0.033498 |
| 0.0003641300 | 122.650 | 0.447968 | 0.235702 | 122.626 | -0.019567 |
| 0.0003598700 | 122.150 | 0.519728 | 0.250000 | 121.152 | -0.816745 |
| 0.0003594800 | 121.650 | 0.253106 | 0.235702 | 121.017 | -0.519939 |
| 0.0003557700 | 120.450 | 0.366843 | 0.235702 | 119.734 | -0.594405 |
| 0.0003532200 | 119.250 | 0.330735 | 0.235702 | 118.851 | -0.333818 |
| 0.0003434400 | 116.750 | 0.276605 | 0.235702 | 115.469 | -1.097436 |
| 0.0003375100 | 114.150 | 0.257723 | 0.250000 | 113.417 | -0.641798 |
| 0.0003362500 | 113.250 | 0.256924 | 0.196116 | 112.981 | -0.237070 |
| 0.0003359599 | 112.700 | 0.404838 | 0.235702 | 112.881 | 0.160778 |
| 0.0003294300 | 112.150 | 1.287780 | 0.235702 | 110.622 | -1.362205 |
| 0.0003297799 | 111.650 | 1.480750 | 0.250000 | 110.743 | -0.812037 |
| 0.0003287100 | 111.150 | 0.368118 | 0.182574 | 110.373 | -0.698859 |
| 0.0003236500 | 109.950 | 0.255738 | 0.250000 | 108.622 | -1.207076 |
| 0.0003209999 | 108.750 | 0.720822 | 0.408248 | 107.706 | -0.959999 |
| 0.0003154600 | 106.250 | 0.475166 | 0.250000 | 105.789 | -0.433254 |
| 0.0003073000 | 103.650 | 0.392473 | 0.250000 | 102.966 | -0.659052 |
| 0.0003058000 | 102.800 | 0.368124 | 0.250000 | 102.447 | -0.342413 |
| 0.0003046000 | 102.250 | 0.387284 | 0.250000 | 102.032 | -0.212337 |
| 0.0003013300 | 101.700 | 0.495741 | 0.235702 | 100.901 | -0.784956 |
| 0.0002993600 | 101.200 | 0.448583 | 0.267261 | 100.220 | -0.968161 |
| 0.0002986199 | 100.700 | 0.281870 | 0.204124 | 99.964 | -0.730652 |
| 0.0002944999 | 99.500 | 0.420329 | 0.250000 | 98.539 | -0.965820 |
| 0.0002899400 | 98.300 | 0.426425 | 0.250000 | 96.961 | -1.361571 |
| 0.0002839000 | 95.800 | 0.263942 | 0.188982 | 94.872 | -0.968509 |
| 0.0002767700 | 93.200 | 0.334161 | 0.250000 | 92.405 | -0.852254 |
| 0.0002773300 | 93.300 | 0.299030 | 0.235702 | 92.599 | -0.750891 |
| 0.0002748299 | 92.750 | 0.264621 | 0.250000 | 91.734 | -1.094773 |
| 0.0002735700 | 92.200 | 0.336684 | 0.267261 | 91.298 | -0.977518 |
| 0.0002742500 | 91.700 | 0.312830 | 0.235702 | 91.533 | -0.181069 |
| 0.0002713100 | 91.200 | 0.330276 | 0.188982 | 90.516 | -0.749980 |
| 0.0002686099 | 90.000 | 0.375413 | 0.250000 | 89.582 | -0.463418 |
| 0.0002618700 | 88.800 | 0.295365 | 0.250000 | 87.251 | -1.743957 |
| 0.0002563399 | 86.300 | 0.267781 | 0.250000 | 85.338 | -1.114273 |
| 0.0002494900 | 83.700 | 0.343911 | 0.235702 | 82.968 | -0.873628 |
| 0.0002477500 | 82.600 | 0.288634 | 0.150755 | 82.366 | -0.282254 |
| 0.0002457100 | 82.050 | 0.350583 | 0.250000 | 81.661 | -0.473901 |
| 0.0002427399 | 81.550 | 0.379602 | 0.250000 | 80.633 | -1.123536 |
| 0.0002442700 | 79.850 | 0.264393 | 0.235702 | 81.163 | 1.644367 |
| 0.0002397600 | 78.650 | 0.290419 | 0.235702 | 79.602 | 1.211557 |
| 0.0002375599 | 76.150 | 0.287583 | 0.235702 | 78.841 | 3.534927 |
| 0.0002318000 | 73.550 | 0.264594 | 0.223606 | 76.849 | 4.485792 |
| 0.0002261200 | 73.100 | 0.474611 | 0.250000 | 74.884 | 2.441077 |
| 0.0002173200 | 72.000 | 0.316483 | 0.182574 | 71.840 | -0.221863 |
| 0.0002212199 | 71.000 | 0.273375 | 0.250000 | 73.189 | 3.083631 |
| 0.0002117900 | 69.800 | 0.343094 | 0.250000 | 69.927 | 0.182341 |

| V/V - V/VO | ACTUAL WEIGHT | STD ERROR OF MEAN IN LBS | E | CALCULATED WEIGHT | PERCENT ERROR |
|---|---|---|---|---|---|
| 0.0002131599 | 68.600 | 0.374079 | 0.223606 | 70.401 | 2.625649 |
| 0.0002045300 | 66.100 | 0.260236 | 0.223606 | 67.415 | 1.990672 |
| 0.0002053099 | 63.500 | 0.654801 | 0.188982 | 67.685 | 6.591587 |
| 0.0001950200 | 59.900 | 1.219550 | 0.250000 | 64.126 | 7.055184 |
| 0.0001867299 | 58.800 | 0.625990 | 0.223606 | 61.258 | 4.180798 |
| 0.0001801800 | 57.200 | 0.236870 | 0.204124 | 58.992 | 2.063112 |
| 0.0001828000 | 56.600 | 0.274864 | 0.408248 | 59.898 | 5.828288 |
| 0.0001722400 | 55.400 | 0.830357 | 0.353553 | 56.245 | 1.526728 |
| 0.0001664499 | 52.900 | 0.280480 | 0.353553 | 54.242 | 2.538529 |
| 0.0001636600 | 50.200 | 0.237963 | 0.353553 | 53.277 | 5.919965 |
| 0.0001671400 | 49.750 | 0.560432 | 0.408248 | 54.481 | 9.510699 |
| 0.0001532600 | 48.650 | 0.109925 | 0.408248 | 49.680 | 2.117342 |
| 0.0001554299 | 47.650 | 0.512599 | 0.235702 | 50.430 | 5.835785 |
| 0.0001521199 | 46.450 | 0.296994 | 0.188982 | 49.631 | 6.849638 |
| 0.0001313699 | 45.250 | 0.412831 | 0.353553 | 42.107 | -6.944275 |
| 0.0001405799 | 42.750 | 0.708653 | 0.408248 | 45.293 | 5.950211 |
| 0.0001401200 | 40.150 | 0.466290 | 0.353553 | 45.134 | 12.414916 |
| 0.0001322000 | 39.600 | 0.566014 | 0.353553 | 42.394 | 7.057667 |
| 0.0001256500 | 38.500 | 0.636892 | 0.353553 | 40.129 | 4.231182 |
| 0.0001172200 | 37.500 | 0.378270 | 0.250000 | 37.212 | -0.765787 |
| 0.0001069000 | 36.300 | 0.390510 | 0.353553 | 33.642 | -7.319975 |
| 0.0001137500 | 35.100 | 0.486590 | 0.353553 | 36.012 | 2.599595 |
| 0.0001141299 | 32.600 | 0.445228 | 0.408248 | 36.143 | 10.870891 |
| 0.0001116300 | 30.000 | 0.517740 | 0.353553 | 35.279 | 17.596966 |
| 0.0001020700 | 29.150 | 0.289448 | 0.353553 | 31.972 | 9.681010 |
| 0.0000924500 | 28.050 | 0.434817 | 0.353553 | 28.644 | 2.118302 |
| 0.0000994599 | 27.050 | 0.393662 | 0.235702 | 27.609 | 2.069715 |
| 0.0000829100 | 25.850 | 0.607149 | 0.408248 | 25.344 | -1.957339 |
| 0.0000765400 | 24.650 | 0.696990 | 0.408248 | 23.140 | -6.123879 |
| 0.0000724900 | 22.150 | 0.641565 | 0.408248 | 21.739 | -1.853481 |
| 0.0000692900 | 19.550 | 0.584725 | 0.408248 | 20.667 | 5.713943 |
| 0.0000610999 | 19.100 | 0.471173 | 0.316227 | 17.799 | -6.809792 |
| 0.0000547199 | 18.000 | 0.700770 | 0.408248 | 15.592 | -13.376073 |
| 0.0000494499 | 17.000 | 0.704803 | 0.316227 | 13.423 | -21.039199 |
| 0.0000482999 | 15.400 | 0.523494 | 0.250000 | 13.367 | -15.392484 |
| 0.0000497800 | 14.600 | 0.300282 | 0.353553 | 13.883 | -4.908073 |
| 0.0000327600 | 12.100 | 0.509966 | 0.353553 | 7.995 | -33.919664 |
| 0.0000302499 | 9.500 | 0.612154 | 0.353553 | 7.127 | -24.974317 |
| 0.0000302400 | 9.600 | 0.432774 | 0.250000 | 7.123 | -25.791865 |
| 0.0000322500 | 8.500 | 0.570890 | 0.353553 | 7.819 | -8.008273 |
| 0.0000247500 | 7.500 | 0.795925 | 0.353553 | 5.224 | -30.335540 |
| 0.0000141399 | 6.300 | 0.343686 | 0.408248 | 1.554 | -75.324855 |
| 0.0000190099 | 5.100 | 0.646477 | 0.353553 | 3.239 | -36.486170 |
| 0.0000073100 | 2.600 | 0.591646 | 0.223606 | -0.808 | -131.082940 |
| 0.0000000000 | 0.000 | 0.586830 | 0.250000 | -3.336 | -333.689274 |

## Table C.IV (c)

**Load Cell Test 3: Diaphragm Connected; Weights Subtracted.**
**(Comparison of calculated and actual weights using calibration curve obtained from test on load cell alone)**

```
SLOPE = .000003003, Y INTERCEPT = 0

V/V - V/VO      ACTUAL WEIGHT    STD ERROR OF      E         CALCULATED WEIGHT   PERCENT ERROR
                                 MEAN IN LBS

0.0003960800       133.900         0.249629     0.235702         131.894           -1.497556
0.0003951500       133.350         0.239830     0.204124         131.588           -1.321025
0.0003927700       132.800         0.443423     0.235702         130.792           -1.511641
0.0003910500       132.300         0.494390     0.267261         130.219           -1.572350
0.0003905800       131.800         0.329635     0.250000         130.063           -1.317700
0.0003855600       130.600         0.474945     0.235702         128.391           -1.690958
0.0003829000       129.400         0.344138     0.250000         127.505           -1.463811
0.0003747600       126.900         0.286887     0.235702         124.795           -1.658524
0.0003676500       124.300         0.352155     0.235702         122.430           -1.503698
0.0003674300       123.750         0.277397     0.196116         122.354           -1.127528
0.0003656700       123.200         0.391461     0.250000         121.768           -1.162149
0.0003641300       122.650         0.447969     0.235702         121.255           -1.137047
0.0003598700       122.150         0.519728     0.250000         119.836           -1.893712
0.0003594900       121.650         0.253106     0.235702         119.706           -1.597238
0.0003557700       120.450         0.366843     0.235702         118.471           -1.642566
0.0003532200       119.250         0.330735     0.235702         117.622           -1.364882
0.0003434400       116.750         0.276605     0.235702         114.365           -2.042283
0.0003375100       114.150         0.257723     0.250000         112.390           -1.541005
0.0003362500       113.250         0.256924     0.196116         111.971           -1.129039
0.0003359599       112.700         0.404838     0.235702         111.874           -0.732216
0.0003294300       112.150         1.287780     0.235702         109.700           -2.184306
0.0003297799       111.650         1.480750     0.250000         109.816           -1.641872
0.0003287100       111.150         0.368119     0.182574         109.460           -1.519982
0.0003236500       109.950         0.255738     0.250000         107.775           -1.977664
0.0003209999       108.750         0.720822     0.408249         106.893           -1.707488
0.0003154600       106.250         0.475166     0.250000         105.048           -1.131025
0.0003073000       103.650         0.392473     0.250000         102.331           -1.272549
0.0003058000       102.800         0.368124     0.250000         101.831           -0.942118
0.0003046000       102.250         0.387284     0.250000         101.431           -0.800096
0.0003013300       101.700         0.495741     0.235702         100.342           -1.334325
0.0002993600       101.200         0.448883     0.267261          99.686           -1.495078
0.0002986199       100.700         0.281870     0.204124          99.440           -1.250685
0.0002944999        99.500         0.420329     0.250000          98.068           -1.438595
0.0002899400        98.300         0.426475     0.250000          96.550           -1.780145
0.0002839000        95.800         0.263942     0.188982          94.538           -1.316497
0.0002767700        93.200         0.334161     0.250000          92.164           -1.111048
0.0002773300        93.300         0.399030     0.235702          92.350           -1.017167
0.0002748299        92.750         0.264621     0.250000          91.518           -1.327782
0.0002735700        92.200         0.336684     0.267261          91.098           -1.194250
0.0002742500        91.700         0.312830     0.235702          91.325           -0.408569
0.0002713100        91.200         0.330276     0.188982          90.346           -0.936052
0.0002686099        90.000         0.375413     0.250000          89.447           -0.614200
0.0002618700        88.800         0.295365     0.250000          87.202           -1.798651
0.0002563399        86.300         0.267781     0.250000          85.361           -1.087711
0.0002494900        83.700         0.343911     0.235702          83.080           -0.740438
0.0002477500        82.600         0.288634     0.150756          82.500           -0.120057
0.0002457100        82.050         0.360583     0.250000          81.821           -0.278474
0.0002427399        81.550         0.379602     0.250000          80.832           -0.879827
0.0002442700        79.850         0.264393     0.235702          81.341            1.868492
0.0002397600        78.650         0.290419     0.235702          79.840            1.513235
0.0002375599        76.150         0.287583     0.235702          79.107            3.883859
0.0002318000        73.550         0.264594     0.223606          77.189            4.948303
```

| V/V - V/VO | ACTUAL WEIGHT | STD ERROR OF MEAN IN LBS | E | CALCULATED WEIGHT | PERCENT ERROR |
|---|---|---|---|---|---|
| 0.0002261200 | 73.100 | 0.474611 | 0.250000 | 75.298 | 3.006888 |
| 0.0002173200 | 72.000 | 0.316483 | 0.182574 | 72.367 | 0.510600 |
| 0.0002212199 | 71.000 | 0.273375 | 0.250000 | 73.666 | 3.755399 |
| 0.0002117900 | 69.900 | 0.343094 | 0.250000 | 70.526 | 1.040316 |
| 0.0002131599 | 68.600 | 0.374079 | 0.223606 | 70.982 | 3.472814 |
| 0.0002045300 | 66.100 | 0.260236 | 0.223606 | 68.108 | 3.038666 |
| 0.0002053099 | 63.500 | 0.654801 | 0.188982 | 68.368 | 7.666611 |
| 0.0001950200 | 59.900 | 1.218550 | 0.250000 | 64.941 | 8.416903 |
| 0.0001867299 | 58.900 | 0.625990 | 0.223606 | 62.181 | 5.750258 |
| 0.0001901800 | 57.800 | 0.236870 | 0.204124 | 60.000 | 3.806228 |
| 0.0001829000 | 56.600 | 0.274964 | 0.408248 | 60.872 | 7.548517 |
| 0.0001722400 | 55.400 | 0.830357 | 0.353553 | 57.355 | 3.530645 |
| 0.0001664499 | 52.900 | 0.280480 | 0.353553 | 55.427 | 4.778649 |
| 0.0001636600 | 50.300 | 0.237963 | 0.353553 | 54.498 | 8.347584 |
| 0.0001671400 | 49.750 | 0.560432 | 0.408248 | 55.657 | 11.874725 |
| 0.0001532600 | 48.650 | 0.109925 | 0.408248 | 51.035 | 4.903660 |
| 0.0001554299 | 47.650 | 0.512599 | 0.235702 | 51.758 | 8.621703 |
| 0.0001531199 | 46.450 | 0.296994 | 0.188982 | 50.989 | 9.771821 |
| 0.0001312699 | 45.250 | 0.412831 | 0.353553 | 43.746 | -3.323196 |
| 0.0001405799 | 42.750 | 0.708653 | 0.408248 | 46.813 | 9.504530 |
| 0.0001401200 | 40.150 | 0.466290 | 0.353553 | 46.660 | 16.214214 |
| 0.0001322000 | 39.600 | 0.566014 | 0.353553 | 44.022 | 11.168293 |
| 0.0001255500 | 38.500 | 0.636892 | 0.353553 | 41.841 | 8.679199 |
| 0.0001172200 | 37.500 | 0.378270 | 0.250000 | 39.034 | 4.091464 |
| 0.0001069000 | 36.300 | 0.390510 | 0.353553 | 35.597 | -1.934611 |
| 0.0001137500 | 35.100 | 0.486590 | 0.353553 | 37.878 | 7.916774 |
| 0.0001141299 | 32.600 | 0.445228 | 0.408248 | 38.005 | 16.580760 |
| 0.0001116300 | 30.000 | 0.517740 | 0.353553 | 37.172 | 23.909424 |
| 0.0001020700 | 29.150 | 0.289448 | 0.353553 | 33.989 | 16.601523 |
| 0.0000924500 | 28.050 | 0.434817 | 0.353553 | 30.785 | 9.753585 |
| 0.0000894599 | 27.050 | 0.393662 | 0.235702 | 29.790 | 10.130165 |
| 0.0000829100 | 25.850 | 0.607149 | 0.408248 | 27.609 | 6.804866 |
| 0.0000765400 | 24.650 | 0.695990 | 0.408248 | 25.487 | 3.398967 |
| 0.0000724900 | 22.150 | 0.641565 | 0.408248 | 24.139 | 8.980560 |
| 0.0000693900 | 19.550 | 0.584725 | 0.408248 | 23.106 | 18.193826 |
| 0.0000610999 | 19.100 | 0.471173 | 0.316227 | 20.346 | 6.525236 |
| 0.0000547199 | 18.000 | 0.700770 | 0.408248 | 18.221 | 1.232100 |
| 0.0000484499 | 17.000 | 0.704803 | 0.316227 | 16.133 | -5.094905 |
| 0.0000482899 | 15.800 | 0.523494 | 0.250000 | 16.080 | 1.775860 |
| 0.0000497800 | 14.600 | 0.300282 | 0.353553 | 16.576 | 13.539431 |
| 0.0000327600 | 12.100 | 0.509966 | 0.353553 | 10.909 | -9.842221 |
| 0.0000302499 | 9.500 | 0.612154 | 0.353553 | 10.073 | 6.034314 |
| 0.0000302400 | 9.600 | 0.432774 | 0.250000 | 10.069 | 4.895106 |
| 0.0000322500 | 8.500 | 0.570890 | 0.353553 | 10.739 | 26.344244 |
| 0.0000247500 | 7.500 | 0.795925 | 0.353553 | 8.241 | 9.890114 |
| 0.0000141399 | 6.300 | 0.343686 | 0.408248 | 4.708 | -25.259927 |
| 0.0000190099 | 5.100 | 0.646477 | 0.353553 | 6.330 | 24.124241 |
| 0.0000073100 | 2.600 | 0.591646 | 0.223606 | 2.434 | -6.375675 |
| 0.0000000000 | 0.000 | 0.586830 | 0.250000 | 0.000 | 0.000000 |

# APPENDIX D

## Orifice Plate Installation and Calibration

**Theory.** Consider the type of constriction in a flow line as shown by Figure D.1.

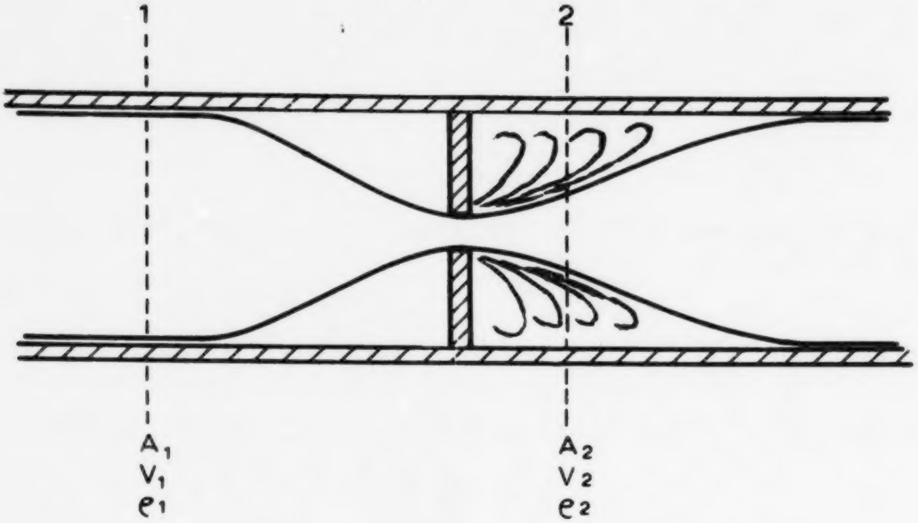

Fig. D.1. Schematic of Orfice Plate Installation

An energy balance between planes 1 and 2 gives

$$\frac{V_1{}^2}{2g} + h_1 + \frac{P_1}{\rho_1} + U_1 = \frac{V_2{}^2}{2g} + h_2 + \frac{P_2}{2} + U_1 + q + w_s \quad \text{(D-1)}$$

Assuming no shaft work ($w_s = 0$), an adiabatic process ($q = 0$) and no difference in elevation between points 1 and 2 ($h_1 = h_2$), equation (D-1) reduces to

$$\frac{V_1{}^2}{2g} + H_1 = \frac{V_2{}^2}{2g} + H_2 \quad \text{(D-2)}$$

where the enthalpy term $H = \frac{P}{\rho} + U$.

From (D-2)

$$\frac{V_1^2-V_2^2}{2g} = H_2 - H_1 \qquad \text{(D-3)}$$

For an ideal gas

$$H_1 - H_2 = \int_{T_1}^{T_2} C_p dT + \frac{k}{k-1}(P_1 v_1 - P_2 v_2)$$

where

$$k = \frac{C_p}{C_v} \qquad \text{and} \qquad v = \frac{1}{\rho}$$

Using the relationship $Pv^k$ = constant for an adiabatic expansion of an ideal gas

$$H_1 - H_2 = P_1 v_1 \left(\frac{k}{k-1}\right)\left[1 - \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}}\right] \qquad \text{(D-4)}$$

Using equations (D-3), (D-4) and the mass balance equation, (D-5)

$$V_1 A_1 \rho_1 = V_2 A_2 \rho_2 \qquad \text{(D-5)}$$

the theoretical mass flow rate through the orifice can be computed in terms of the measured pressure drop

$$W = \frac{A_2 Y}{\sqrt{1-\left(\frac{A_2}{A_1}\right)^2}} \sqrt{2g\ \rho_1 (P_1 - P_2)} \qquad \text{(D-6)}$$

where the discharge coefficient, Y is given by

$$Y = \sqrt{\frac{\left[1-\left(\frac{A_2}{A_1}\right)^2\right]\left(\frac{k}{k-1}\right)\left[\frac{P_2}{P_1}\right]^{2/k}\left[1-\left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}}\right]}{\left[1-\left(\frac{A_2}{A_1}\right)^2\left(\frac{P_2}{P_1}\right)^{2/k}\right]\left[1-\frac{P_2}{P_1}\right]}} \qquad \text{(D-7)}$$

Experimental values for Y obtained on orifice plates do not agree with theoretical predictions and empirical relationships are resorted to. Equation (D-6) has been developed for gas measurement in A.G.A. Report No. 3 (158) into the following form

$$Q_h = 218.44d^2k \frac{T_b}{P_b} \sqrt{\frac{\Delta P_w P_f}{T_f G}} \tag{D-8}$$

where

$d$ = orifice diameter, inches
$G$ = specific gravity of gas
$\Delta P_w$ = pressure differential, inches of water
$K$ = experimental discharge coefficient
$P_b$ = pressure base, psia
$P_f$ = static pressure of flowing gas, psia
$Q_h$ = rate of gas flow at base conditions, $ft^3/hr$
$T_b$ = temperature base, °R
$T_f$ = flowing temperature of gas, °R

The discharge coefficient K is usually written as

$$K = K_o F_r Y$$

where $K_o$ is a constant for any given orifice size in any given pipe size. $F_r$ is a correction coefficient to account for viscous forces and Y a correction coefficient to account for gas compressibility. As mentioned above, Y is obtained from empirical rather than theoretical considerations, since it is found to be significantly different from the relationship given in equation (D-7). For convenience the portion of equation (D-8) which remains roughly constant is lumped together into one constant, $F_b$, given by

$$F_b = \frac{218.44d^2 K_o T_b}{P_b \sqrt{T_f G}} \tag{D-9}$$

which, with $T_b$ = 520°R, $P_b$ = 14.73 psia, $T_f$ = 520°F and $G = 1.0$ gives

$$F_b = 338.17\ K_o \beta^2 D^2 \tag{D-10}$$

where $\beta$ is the ratio of the diameter of the orifice (d) to that of the pipe (D). Thus, equation (D-8) can be written

$$Q_h = F_b\sqrt{\Delta P_w P_f} \qquad \text{(D-11)}$$

Various correction factors need to be applied to equation (D-11) to take into account viscous and compressibility factors, deviations from ideal gas behavior and changes in base and flowing conditions. The complete equation is then given by

$$Q_h = F_b F_r Y F_{Pb} F_{tb} F_{tf} F_g F_{p\sigma} F_{wv} F_a F_m \sqrt{\Delta P_w P_f} \qquad \text{(D-12)}$$

The various correction factors are discussed below.

Reynolds Number Factor ($F_r$). This factor takes into account the effect of viscous forces on the discharge coefficient and is empirically given, for flange taps, by

$$F_r = 1 + \frac{E}{Re_D}$$

where

$$E = d(830 - 5000\beta + 9000\beta^2 - 4200\beta^3 + \frac{530}{\sqrt{D}})$$

and

$Re_D$ = flow Reynolds number based on the inside diameter of the pipe

Compressibility Factor (Y). An empirical factor which acts as a correction to the discharge coefficient and given, for flange taps, by

$$Y = 1 - (0.41 + 0.35\beta^4)\frac{x}{k}$$

where

$$x = \frac{\Delta P_w}{27.7 P_{f_1}}$$

and $P_{f_1}$ = upstream flowing pressure (psia)

Other Corrections to $F_b$ ($F_{Pb}$, $F_{tb}$, $F_{tf}$, $F_g$). Assumed values for $P_b$, $T_b$, $T_f$ and G where used in calculating $F_b$ in equation (D-10) and corrections for actual base and flowing conditions must be made as follows

$$F_{Pb} = \frac{14.73}{Pb}$$

$$F_{tb} = \frac{T_b}{520}$$

$$F_{tf} = \sqrt{\frac{520}{Tf}}$$

$$Fg = \sqrt{\frac{1}{G}}$$

These correction factors are the most important for the purposes of this work. Less important ones are discussed below.

Deviation from Ideal Gas Behavior ($F_Z$). This factor takes into account deviations from the ideal gas behavior which was assumed in the correction used for temperature and pressure. The factor is given by

$$F_Z = \sqrt{\frac{Z_b}{Z_f}}$$

where

$Z_b$ = compressibility factor at base conditions

$Z_f$ = compressibility factor at flowing conditions

Manometer Factor (Fm). This factor corrects the pressure differential that is measured across the orifice for the difference in density between the manometric fluid and the gas. Water vapor correction ($F_{wv}$). This corrects the volume flow to a moisture percentage other than that corresponding to the flowing conditions. Correction for Temperature Expansion of Orifice ($F_a$). This factor corrects for the change in orifice diameter, d, at temperatures different from base conditions.

Calculation of Flow Charts. Equation (D-12) was used for the computation of gas flow rates at different flowing pressures, temperature and pressure drops across the orifice. The values of the factors and constants are summarized below in Table D.I.

The results of the calculations are set forth at the end of this section. The table gives the gas flow rate in cubic feet per minute at 60°F and 14.70 psia and in lb moles/min for different values of $\Delta P_w P_f$ (in. water mm Hg) at different flowing temperatures. These tables were generated with the correct value of $F_r$ for each flow rate. The flow rates must be corrected by multiplying them by the appropriate Y factor if Y is sufficiently different from 0.99. A second table gives Y as a function of $\frac{\Delta P_w}{P_f} \quad \frac{\text{ins } H_2O}{\text{mm Hg}}$ .

Installation of Orifice Plates. It is very important to install orifice plates in the correct hydrodynamic conditions; otherwise serious errors will result. The orifice plates used to measure the overfire and underfire air flow rates are all installed according to A.G.A. regulations. Assuming that the approach conditions set up by the flexible tubing roughly approximate having two elbows in different planes preceding the calming section, the length of the calming section for a β of 0.41 should be 18 pipe diameters. There should also be 4 pipe diameters of unconstricted flow downstream of the orifice plate. These lengths can be reduced to 10 pipe diameters and 4 pipe diameters if straightening vanes precede the orifice plate. The actual conditions chosen for the installation of the orifice plates consisted of 31 pipe diameters before and 24 pipe diameters following the orifice plates. Straightening vanes were also used at the entrance of the calming section.

| Factor \ β | 0.41291 | 0.63483 |
|---|---|---|
| $K_o\beta^2$ | 0.10412 | 0.26787 |
| $D^2$ | 4.27249 in. | 4.27249 |
| d | 0.8585 in. | 1.312 |
| $F_m$ | 1.0 | 1.0 |
| $F_a$ | 1.0 | 1.0 |
| $F_{fv}$ | 1.0 | 1.0 |
| $F_g$ | 1.0 | 1.0 |
| $F_{wv}$ | 1.0 | 1.0 |
| $F_{tb}$ | 1.0 | 1.0 |
| $F_{Pb}$ | $\frac{14.73}{14.70} = 1.00204$ | 1.00204 |
| $F_b$ | 150.44 | 387.03 |
| $F_r$ | variable which changes as $Q_h$ changes | |
| Y | 0.99000 | 0.99000 |

Table D.I. Factors for Orfice Plate Calculations

### FORTRAN PROGRAM FOR CALCULATING FLOW RATES THROUGH ORIFICE PLATES AS A FUNCTION OF GAS TEMPERATURE AND STATIC PRESSURE AND ORIFICE PRESSURE DROP.

```
      REAL MU
      DIMENSION ANSW(9),ITF(9)
    2 WRITE(3,201)
  201 FORMAT('1',20X,'TARLE OF HWP (INS. H2O*MM. HG) AT VARIOUS TEMPERA
     1TURES AND WITH Y1=0.99')
      WRITE(3,202)
  202 FORMAT(//,40X,'Q1=FT3/MIN AT 60 DEG F AND 14.70 PSIA ')
      WRITE(3,203)
  203 FORMAT( /,40X,'Q2=LB. MOLES/MIN AT 60 DEG F AND 14.70 PSIA ',//)
      READ(2,100) D,DP,AKOB2,PB,TB,QI
  100 FORMAT(6F10.5)
      PEAD(2,101) ITF(1)
  101 FORMAT(I10)
      DO 20 JJ = 2, 9
   2u ITF(JJ)=ITF(JJ-1)+10
      Y1 = .99
      A=-4.69577
      C=0.0012547
      BETA=D/DP
      FPB=14.73/PB
      FTB=TB/520.0
      FB=338.17*AKOB2*DP*DP
      AA=SQRT(51.72)
      ANO=FPB*FB/(60.0*AA)
      EF=D*(830.0-5000.0*BETA+9000.0*BETA*BETA-4200.0*BETA**3+530.0/
     1SQRT(DP))
      WRITE(3,204) BETA
  204 FORMAT(//,37X,'BETA = ',F6.4,'  (RATIO OF ORIFICE DIAM TO PIPE DIA
     1M )',//)
      WRITE(3,200) (ITF(JJ),JJ=1,9)
  200 FORMAT(7X,'Q1',7X,'Q2',4X,9(I5,' DEG F')///)
      Q=QI-0.2
      DO 9 J9 = 1, 301
      TF=ITF(1)+460.0
      Q = Q + .2
      DO 1 J = 1, 9
      FTF = SQRT(520. / TF)
      MU = EXP(A + C * TF)
      MU=MU*2.42
      QQ=Q *492.0*28.8/(359.0*520.0)
      QQ=QQ*60.0
      G=4.0*144.0*QQ/(DP*DP*3.1416)
      RD=G*DP/(MU*12.0)
      FR=1.0+EF*BETA/RD
      HWP = (Q / ANO / FTF / FR / Y1 ) ** 2
      TF = TF + 10.
      ANSW(J) = HWP
1     CONTINUE
      Q2=QQ/(60.0*28.8)
      WRITE(3,3) Q,Q2,(ANSW(JJ),JJ=1,9)
3     FORMAT(F10.3,F10.5,9F11.4)
9     CONTINUE
      GO TO 2
      END
```

### FORTRAN PROGRAM FOR CALCULATING COMPRESSIBILITY FACTOR (Y) AS A FUNCTION OF GAS STATIC PRESSURE AND ORIFICE PRESSURE DROP.

```
      REAL N,K
      WRITE(3, 30)
30    FORMAT('1Y1 = .99'//)
      WRITE(3,1)
1     FORMAT('             HW/PI F                   Y1                 F Y1'
     1)
      B4 = (.4129171) ** 4
      K = 1.4
      HWAP = 1./800.
      DO 2 JJ = 1, 100
      N = HWAP/27.7/.01933
      Y1 = 1. - (.41 + .35 * B4) * N / K
      FY1 = Y1 / .99
      WRITF(3,3) HWAP,Y1,FY1
3     FCRMAT(3F20.8)
      HWAP = HWAP + 30./80000.
2     CONTINUF
      CALL EXIT
      END
```

## TABLE D.II.

**Calculation of Flow Rates through Orifice Plate as a Function of Orifice Pressure Drop and Air Temperature and Static Upstream Pressure.**

($\beta = 0.4129$)

TABLE OF [illegible] AT VARIOUS TEMPERATURES AND WITH Y1=0.99

Q1=FT3/MIN AT 60 DEG F AND 14.73 PSIA

Q2=LB. MOLES/MIN

BETA = 0.4129 (RATIO OF ORIFICE DIAM TO PIPE DIAM )

| Q1 | Q2 | 60 DEG F | 70 DEG F | 80 DEG F | 90 DEG F | 100 DEG F | 110 DEG F | 120 DEG F | 130 DEG F | 140 DEG F |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.000 | 0.00000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.200 | 0.00053 | 0.1000 | 0.1008 | 0.1015 | 0.1022 | 0.1028 | 0.1035 | 0.1040 | 0.1046 | 0.1051 |
| 0.400 | 0.00105 | 0.6689 | 0.6767 | 0.6844 | 0.6918 | 0.6991 | 0.7062 | 0.7130 | 0.7197 | 0.7262 |
| 0.600 | 0.00158 | 1.8482 | 1.8735 | 1.8984 | 1.9228 | 1.9468 | 1.9704 | 1.9935 | 2.0162 | 2.0384 |
| 0.800 | 0.00211 | 3.6721 | 3.7268 | 3.7805 | 3.8336 | 3.8859 | 3.9375 | 3.9884 | 4.0385 | 4.0879 |
| 0.999 | 0.00263 | 6.1530 | 6.2489 | 6.3437 | 6.4376 | 6.5304 | 6.6222 | 6.7130 | 6.8027 | 6.8913 |
| 1.199 | 0.00316 | 9.2954 | 9.4452 | 9.5937 | 9.7409 | 9.8867 | 10.0311 | 10.1741 | 10.3158 | 10.4560 |
| 1.399 | 0.00369 | 13.1022 | 13.3186 | 13.5333 | 13.7464 | 13.9577 | 14.1674 | 14.3753 | 14.5815 | 14.7859 |
| 1.599 | 0.00421 | 17.5769 | 17.8725 | 18.1642 | 18.4558 | 18.7454 | 19.0330 | 19.3186 | 19.6018 | 19.8830 |
| 1.799 | 0.00474 | 22.7161 | 23.1019 | 23.4873 | 23.8702 | 24.2508 | 24.6290 | 25.0047 | 25.3780 | 25.7488 |
| 1.999 | 0.00527 | 28.5210 | 29.0135 | 29.5032 | 29.9903 | 30.4746 | 30.9562 | 31.4350 | 31.9109 | 32.3839 |
| 2.199 | 0.00579 | 34.9954 | 35.6054 | 36.2125 | 36.8164 | 37.4173 | 38.0150 | 38.6096 | 39.2010 | 39.7891 |
| 2.399 | 0.00632 | 42.1374 | 42.8782 | 43.6153 | 44.3489 | 45.0792 | 45.8059 | 46.5291 | 47.2487 | 47.9646 |
| 2.599 | 0.00685 | 49.9482 | 50.8319 | 51.7119 | 52.5881 | 53.4604 | 54.3290 | 55.1936 | 56.0542 | 56.9108 |
| 2.799 | 0.00737 | 58.4271 | 59.4667 | 60.5024 | 61.5339 | 62.5613 | 63.5845 | 64.6033 | 65.6178 | 66.6279 |
| 2.999 | 0.00790 | 67.5741 | 68.7827 | 69.9869 | 71.1867 | 72.3819 | 73.5725 | 74.7584 | 75.9396 | 77.1160 |
| 3.199 | 0.00843 | 77.3897 | 78.7800 | 80.1656 | 81.5464 | 82.9223 | 84.2932 | 85.6590 | 87.0197 | 88.3753 |
| 3.399 | 0.00896 | 87.8737 | 89.4597 | 91.0385 | 92.6132 | 94.1825 | 95.7466 | 97.3052 | 98.8583 | 100.4058 |
| 3.599 | 0.00948 | 99.0246 | 100.8188 | 102.6057 | 104.3870 | 106.1628 | 107.9328 | 109.6970 | 111.4553 | 113.2076 |
| 3.799 | 0.01001 | 110.8475 | 112.8603 | 114.8671 | 116.8692 | 118.8630 | 120.8518 | 122.8344 | 124.8108 | 126.7808 |
| 3.999 | 0.01054 | 123.3375 | 125.5833 | 127.8229 | 130.0562 | 132.2832 | 134.5037 | 136.7177 | 138.9249 | 141.1255 |
| 4.199 | 0.01106 | 136.4960 | 138.9878 | 141.4730 | 143.9516 | 146.4235 | 148.8885 | 151.3466 | 153.7977 | 156.2416 |
| 4.399 | 0.01159 | 150.3232 | 153.0739 | 155.8176 | 158.5563 | 161.2839 | 164.0063 | 166.7216 | 169.4291 | 172.1292 |
| 4.599 | 0.01212 | 164.8191 | 167.8414 | 170.8565 | 173.8642 | 176.8644 | 179.8571 | 182.8420 | 185.8194 | 188.7843 |
| 4.799 | 0.01265 | 179.9837 | 183.2906 | 186.5899 | 189.8816 | 193.1651 | 196.4468 | 199.7064 | 202.9679 | 206.2190 |
| 4.999 | 0.01317 | 195.8171 | 199.4213 | 203.0176 | 206.6059 | 210.1859 | 213.7575 | 217.3207 | 220.8753 | 224.4212 |
| 5.199 | 0.01370 | 212.3102 | 216.2337 | 220.1399 | 224.0376 | 227.9268 | 231.8073 | 235.6759 | 239.5415 | 243.3950 |
| 5.399 | 0.01423 | 229.4900 | 233.7276 | 237.9566 | 242.1767 | 246.3879 | 250.5900 | 254.7829 | 258.9664 | 263.1404 |
| 5.599 | 0.01475 | 247.3295 | 251.9032 | 256.4577 | 261.0232 | 265.5692 | 270.1059 | 274.6329 | 279.1501 | 283.6574 |
| 5.799 | 0.01528 | 265.8375 | 270.7603 | 275.6734 | 280.5769 | 285.4707 | 290.3547 | 295.2287 | 300.0926 | 304.9461 |
| 5.999 | 0.01581 | 285.0149 | 290.2991 | 295.5739 | 300.8380 | 306.0924 | 311.3366 | 316.5705 | 321.7938 | 327.0063 |
| 6.199 | 0.01634 | 304.8604 | 310.5195 | 316.1681 | 321.8066 | 327.4343 | 333.0516 | 338.6582 | 344.2536 | 349.8383 |
| 6.399 | 0.01686 | 325.3754 | 331.4215 | 337.4572 | 343.4822 | 349.4966 | 355.4997 | 361.4918 | 367.4725 | 373.4416 |
| 6.599 | 0.01739 | 346.5598 | 353.0052 | 359.4408 | 365.8654 | 372.2788 | 378.6808 | 385.0713 | 391.4501 | 397.8170 |
| 6.799 | 0.01792 | 368.4117 | 375.2706 | 382.1189 | 388.9559 | 395.7813 | 402.5950 | 409.3968 | 416.1865 | 422.9639 |
| 6.999 | 0.01844 | 390.9320 | 398.2174 | 405.4915 | 412.7538 | 420.0041 | 427.2423 | 434.4682 | 441.6817 | 448.8824 |
| 7.199 | 0.01897 | 414.1217 | 421.8461 | 429.5586 | 437.2590 | 444.9471 | 452.6227 | 460.2856 | 467.9356 | 475.5726 |
| 7.399 | 0.01950 | 437.9803 | 446.1564 | 454.3202 | 462.4716 | 470.6103 | 478.7362 | 486.8489 | 494.9484 | 503.0344 |
| 7.599 | 0.02002 | 462.5076 | 471.1493 | 479.7764 | 488.3916 | 496.9938 | 505.5827 | 514.1592 | 522.7200 | 531.2680 |
| 7.799 | 0.02055 | 487.7034 | 496.8219 | 505.9270 | 515.0189 | 524.0975 | 533.1626 | 542.2136 | 551.2504 | 560.2732 |
| 7.999 | 0.02108 | 513.5687 | 523.1771 | 532.7722 | 542.3537 | 551.9214 | 561.4751 | 571.0146 | 580.5397 | 590.0500 |
| 8.199 | 0.02161 | 540.1025 | 550.2140 | 560.3119 | 570.3958 | 580.4656 | 590.5210 | 600.5618 | 610.5877 | 620.5986 |
| 8.399 | 0.02213 | 567.3050 | 577.9326 | 588.5461 | 599.1453 | 609.7300 | 620.2999 | 630.8549 | 641.3946 | 651.9189 |
| 8.599 | 0.02266 | 595.1763 | 606.3328 | 617.4748 | 628.6022 | 639.7147 | 650.8120 | 661.8940 | 672.9603 | 684.0108 |
| 8.799 | 0.02319 | 623.7165 | 635.4146 | 647.0981 | 658.7664 | 670.4196 | 682.0572 | 693.6790 | 705.2849 | 716.8744 |
| 8.999 | 0.02371 | 652.9254 | 665.1782 | 677.4158 | 689.6381 | 701.8447 | 714.0355 | 726.2100 | 738.3682 | 750.5097 |
| 9.199 | 0.02424 | 682.8031 | 695.6234 | 708.4281 | 721.2171 | 733.9901 | 746.7468 | 759.4870 | 772.2104 | 784.9167 |
| 9.399 | 0.02477 | 713.3497 | 726.7503 | 740.1350 | 753.5036 | 766.8558 | 780.1913 | 793.5100 | 806.8114 | 820.0954 |
| 9.599 | 0.02530 | 744.5650 | 758.5588 | 772.5363 | 786.4976 | 800.4417 | 814.3689 | 828.2789 | 842.1713 | 856.0458 |
| 9.799 | 0.02582 | 776.4692 | 791.0490 | 805.6322 | 820.1986 | 834.7478 | 849.2797 | 863.7938 | 878.2900 | 892.7679 |
| 9.999 | 0.02635 | 809.0022 | 824.2209 | 839.4226 | 854.6072 | 869.7742 | 884.9235 | 900.0547 | 915.1675 | 930.2617 |
| 10.199 | 0.02688 | 842.2240 | 858.0744 | 873.9076 | 889.7232 | 905.5209 | 921.3005 | 937.0616 | 952.8039 | 968.5272 |
| 10.399 | 0.02740 | 876.1146 | 892.6096 | 909.0871 | 925.5466 | 941.9878 | 958.4105 | 974.8144 | 991.1991 | 1007.5643 |
| 10.599 | 0.02793 | 910.6762 | 927.8265 | 944.9611 | 962.0773 | 979.1750 | 996.2537 | 1013.3132 | 1030.3531 | 1047.3732 |
| 10.799 | 0.02846 | 945.9027 | 963.7251 | 981.5296 | 999.3155 | 1017.0824 | 1034.8300 | 1052.5580 | 1070.2660 | 1087.9538 |
| 10.999 | 0.02899 | 981.7992 | 1000.3053 | 1018.7927 | 1037.2611 | 1055.7101 | 1074.1394 | 1092.5487 | 1110.9377 | 1129.3061 |
| 11.199 | 0.02951 | 1018.3650 | 1037.5672 | 1056.7504 | 1075.9141 | 1095.0580 | 1114.1820 | 1133.2855 | 1152.3683 | 1171.4301 |
| 11.399 | 0.03004 | 1055.5997 | 1075.5138 | 1095.4025 | 1115.2744 | 1135.1262 | 1154.9576 | 1174.7682 | 1194.5577 | 1214.3258 |
| 11.599 | 0.03057 | 1093.5031 | 1114.1361 | 1134.7492 | 1155.3422 | 1175.9147 | 1196.4664 | 1216.9969 | 1237.5060 | 1257.9932 |
| 11.799 | 0.03109 | 1132.0754 | 1153.4430 | 1174.7904 | 1196.1173 | 1217.4234 | 1238.7103 | 1259.9716 | 1281.2131 | 1302.4322 |
| 11.999 | 0.03162 | 1171.3165 | 1193.4316 | 1215.5262 | 1237.5999 | 1259.6524 | 1281.6833 | 1303.6923 | 1325.6790 | 1347.6430 |
| 12.199 | 0.03215 | 1211.2264 | 1234.1019 | 1256.9565 | 1279.7898 | 1302.6046 | 1325.3914 | 1348.1589 | 1370.9038 | 1393.6256 |
| 12.399 | 0.03268 | 1251.8051 | 1275.4538 | 1299.0813 | 1322.6872 | 1346.2711 | 1369.8327 | 1393.3716 | 1416.8876 | 1440.3798 |
| 12.599 | 0.03320 | 1293.0526 | 1317.4875 | 1341.9007 | 1366.2919 | 1390.6605 | 1415.0071 | 1439.3302 | 1463.6299 | 1487.9057 |
| 12.799 | 0.03373 | 1334.9690 | 1360.2028 | 1385.4140 | 1410.6041 | 1435.7709 | 1460.9146 | 1486.0348 | 1511.1312 | 1536.2033 |
| 12.999 | 0.03426 | 1377.5541 | 1403.5987 | 1429.6230 | 1455.6236 | 1481.6012 | 1507.5552 | 1533.4854 | 1559.3913 | 1585.2726 |
| 13.199 | 0.03478 | 1420.8081 | 1447.6784 | 1474.5260 | 1501.3506 | 1528.1517 | 1554.9289 | 1581.6820 | 1608.4103 | 1635.1137 |
| 13.399 | 0.03531 | 1464.7309 | 1492.4387 | 1520.1236 | 1547.7849 | 1575.4225 | 1603.0358 | 1630.6245 | 1658.1882 | 1685.7264 |
| 13.599 | 0.03584 | 1509.3225 | 1537.8807 | 1566.4156 | 1594.9267 | 1623.4135 | 1651.8758 | 1680.3131 | 1708.7249 | 1737.1109 |
| 13.799 | 0.03637 | 1554.5829 | 1584.0044 | 1613.4022 | 1642.7758 | 1672.1249 | 1701.4489 | 1730.7476 | 1760.0204 | 1789.2670 |
| 13.999 | 0.03689 | 1600.5121 | 1630.8098 | 1661.0836 | 1691.3326 | 1721.5565 | 1751.7552 | 1781.9281 | 1812.0748 | 1842.1949 |
| 14.199 | 0.03742 | 1647.1152 | 1678.2960 | 1709.4590 | 1740.5963 | 1771.7083 | 1802.7945 | 1833.8546 | 1864.8881 | 1895.8945 |
| 14.399 | 0.03795 | 1694.3772 | 1726.4656 | 1758.5293 | 1790.5677 | 1822.5806 | 1854.5670 | 1886.5271 | 1918.4632 | 1950.3658 |
| 14.599 | 0.03847 | 1742.3127 | 1775.3160 | 1808.2940 | 1841.2464 | 1874.1728 | 1907.0726 | 1939.9456 | 1972.7911 | 2005.6088 |
| 14.799 | 0.03900 | 1790.9172 | 1824.8460 | 1858.7533 | 1892.6326 | 1926.4854 | 1960.3114 | 1994.1100 | 2027.8809 | 2061.6235 |
| 14.999 | 0.03953 | 1840.1905 | 1875.0618 | 1909.9072 | 1944.7262 | 1979.5183 | 2014.2833 | 2049.0205 | 2083.7295 | 2118.4099 |
| 15.199 | 0.04005 | 1890.1326 | 1925.9572 | 1961.7555 | 1997.5271 | 2033.2715 | 2068.9882 | 2104.6769 | 2140.3370 | 2175.9680 |
| 15.399 | 0.04058 | 1940.7436 | 1977.5344 | 2014.2985 | 2051.0359 | 2087.7444 | 2124.4246 | 2161.0793 | 2197.7033 | 2234.2979 |
| 15.599 | 0.04111 | 1992.0234 | 2029.7932 | 2067.5359 | 2105.2512 | 2142.9345 | 2180.5976 | 2218.2277 | 2255.8262 | 2293.3996 |
| 15.799 | 0.04164 | 2043.9721 | 2082.7326 | 2121.4679 | 2160.1744 | 2198.8526 | 2237.5020 | 2276.1221 | 2314.7125 | 2353.2727 |
| 15.999 | 0.04216 | 2094.5881 | 2134.3558 | 2174.0965 | 2213.8050 | 2253.4668 | 2293.1343 | 2332.7625 | 2372.3554 | 2411.9177 |
| 16.199 | 0.04269 | 2149.8756 | 2190.6596 | 2231.4198 | 2272.1429 | 2312.8413 | 2353.5211 | 2394.1609 | 2434.7571 | 2475.3343 |
| 16.399 | 0.04322 | 2203.8376 | 2245.6451 | 2287.4312 | 2329.1943 | 2370.9160 | 2412.6130 | 2454.2814 | 2495.9177 | 2537.5247 |
| 16.599 | 0.04375 | 2258.4544 | 2301.3123 | 2344.1413 | 2386.9411 | 2429.7111 | 2472.4537 | 2515.1596 | 2557.8374 | 2600.4828 |
| 16.799 | 0.04427 | 2313.7571 | 2357.6662 | 2401.5460 | 2445.4013 | 2489.2263 | 2533.0207 | 2576.7639 | 2620.5154 | 2664.2147 |
| 16.999 | 0.04480 | 2369.7086 | 2414.6917 | 2459.6453 | 2504.5688 | 2549.4612 | 2594.3239 | 2639.1542 | 2683.9525 | 2728.7182 |
| 17.199 | 0.04533 | 2426.3387 | 2472.4039 | 2518.4391 | 2564.4438 | 2610.4177 | 2656.3606 | 2702.2705 | 2748.1465 | 2793.9984 |
| 17.399 | 0.04585 | 2483.6380 | 2530.7978 | 2577.9274 | 2625.0262 | 2672.0937 | 2719.1294 | 2766.1328 | 2813.1033 | 2860.0404 |
| 17.599 | 0.04638 | 2541.6097 | 2589.8734 | 2638.1103 | 2686.3163 | 2734.4934 | 2782.6343 | 2830.7411 | 2878.8170 | 2926.8590 |
| 17.799 | 0.04691 | 2600.2427 | 2649.6307 | 2698.9877 | 2748.3132 | 2797.6067 | 2846.8576 | 2896.0994 | 2945.2845 | 2994.4494 |
| 17.999 | 0.04743 | 2659.5481 | 2710.0698 | 2760.5596 | 2811.0178 | 2861.4435 | 2911.8363 | 2962.1956 | 3012.5204 | 3062.8115 |
| 18.199 | 0.04796 | 2719.5227 | 2771.1903 | 2822.8261 | 2874.4299 | 2926.0007 | 2977.5382 | 3029.0449 | 3080.5111 | 3131.9453 |
| 18.399 | 0.04849 | 2780.1653 | 2832.9876 | 2885.7872 | 2938.5492 | 2991.2781 | 3043.9732 | 3096.6341 | 3149.2602 | 3201.8508 |

|  |  |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|
| 18.599 | [illegible] | [illegible] | [illegible] | [illegible] | 3003.3760 | [illegible] | 3111.1614 | 3164.9724 | 3218.7481 | 3274.5241 |
| 18.799 | [illegible] | [illegible] | [illegible] | [illegible] | 3059.9108 | 3123.4953 | 3179.2466 | 3234.2566 | 3289.1349 | 3343.9770 |
| 18.999 | [illegible] | 2964.1084 | 3021.4009 | 3078.4775 | 3135.1518 | 3191.4414 | 3247.4773 | 3303.3468 | [illegible] | 3416.1976 |
| 19.199 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 19.399 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 19.599 | [illegible] | [illegible] | 3214.1217 | [illegible] | 3334.1211 | [illegible] | [illegible] | 3527.6533 | 3577.6925 | [illegible] |
| 19.799 | 0.05216 | 3227.1957 | [illegible] | 3352.5416 | 3437.1421 | 3484.3973 | 3524.5434 | 3590.6675 | 3651.7546 | 3712.7974 |
| 19.999 | 0.05271 | 3294.3865 | 3351.4519 | 3414.4780 | 3474.0712 | 3530.4248 | 3601.8659 | 3664.4277 | 3726.5714 | 3788.0766 |
| 20.199 | 0.05321 | 3344.4515 | 3410.4890 | 3463.4909 | 3547.4970 | 3611.1856 | 3674.8791 | 3730.5338 | 3824.1504 | 3865.7475 |
| 20.399 | 0.05374 | 3427.3903 | 3484.5042 | 3557.5074 | 3514.6504 | 3583.6567 | 3748.6454 | 3813.5659 | 3875.4876 | 3943.3502 |
| 20.599 | 0.05424 | 3441.5937 | 3557.4098 | 3624.1904 | 3603.5513 | 3755.8670 | 3823.1448 | 3889.3841 | 3955.5542 | 4021.7445 |
| 20.799 | 0.05481 | 3560.4524 | 3627.7013 | 3695.4036 | 3757.1595 | 3839.7878 | 3894.3773 | 3965.9282 | 4033.4345 | 4100.4150 |
| 20.999 | 0.05536 | 3620.3902 | 3694.4554 | 3767.4440 | 3835.4752 | 3905.4284 | 3974.3430 | 4043.2183 | 4112.0536 | 4180.8484 |
| 21.199 | 0.05587 | 3696.7984 | 3743.4012 | 3840.1408 | 3910.4933 | 3980.7995 | 4051.0410 | 4121.2544 | 4191.4266 | 4261.5579 |
| 21.399 | 0.05640 | 3772.0722 | 3841.6297 | 3919.5474 | 3945.2287 | 4056.8704 | 4128.4737 | 4200.0365 | 4271.5589 | 4343.0391 |
| 21.599 | 0.05692 | 3841.4164 | 3914.5379 | 3987.6215 | 4063.6666 | 4133.6726 | 4206.6588 | 4279.5645 | 4352.4402 | 4425.2040 |
| 21.799 | 0.05745 | 3913.4207 | 3987.3298 | 4062.3498 | 4136.9119 | 4211.1945 | 4285.5370 | 4359.8388 | 4434.0987 | 4508.3166 |
| 21.999 | 0.05798 | 3984.1114 | 4047.2016 | 4137.9526 | 4213.6645 | 4289.4367 | 4365.1683 | 4440.8587 | 4516.5071 | 4592.1130 |
| 22.199 | 0.05850 | 4055.4624 | 4135.7556 | 4214.3090 | 4291.2246 | 4368.3941 | 4445.5327 | 4522.6247 | 4599.6744 | 4676.6811 |
| 22.399 | 0.05903 | 4133.4823 | 4212.1013 | 4293.4618 | 4369.4921 | 4448.3018 | 4526.6303 | 4605.1367 | 4683.6005 | 4762.0208 |
| 22.599 | 0.05956 | 4208.1704 | 4289.3091 | 4368.4082 | 4449.4670 | 4528.4848 | 4608.4610 | 4688.3948 | 4768.2055 | 4848.1323 |
| 22.799 | 0.06008 | 4287.4276 | 4365.1094 | 4446.6492 | 4529.1493 | 4609.6081 | 4691.1240 | 4772.3988 | 4853.7293 | 4935.0155 |
| 22.999 | 0.06061 | 4360.4534 | 4447.5003 | 4525.5467 | 4609.5390 | 4691.4516 | 4774.3218 | 4857.1488 | 4939.9319 | 5022.6705 |
| 23.199 | 0.06114 | 4436.7485 | 4520.7523 | 4605.2147 | 4689.0361 | 4774.0156 | 4858.3518 | 4942.6449 | 5026.8934 | 5111.0971 |
| 23.399 | 0.06167 | 4513.4122 | 4599.5963 | 4685.5393 | 4771.4426 | 4857.2094 | 4943.1151 | 5028.8868 | 5114.6138 | 5200.2955 |
| 23.599 | 0.06219 | 4591.4467 | 4678.1723 | 4766.5585 | 4853.0525 | 4941.3033 | 5028.6114 | 5115.8747 | 5203.0930 | 5290.2655 |
| 23.799 | 0.06272 | 4672.3460 | 4758.1302 | 4848.2722 | 4937.1719 | 5026.0283 | 5114.8409 | 5203.6087 | 5292.3311 | 5381.0073 |
| 23.999 | 0.06325 | 4746.7161 | 4840.4103 | 4930.6824 | 5021.0966 | 5111.4732 | 5201.8035 | 5292.0887 | 5382.3280 | 5472.5208 |
| 24.199 | 0.06377 | 4820.7551 | 4921.7904 | 5013.7832 | 5105.7327 | 5197.6303 | 5289.4992 | 5381.3146 | 5473.0838 | 5564.8060 |
| 24.399 | 0.06430 | 4910.4623 | 5004.0631 | 5097.5805 | 5191.0743 | 5284.5237 | 5377.9280 | 5471.2866 | 5564.5985 | 5657.8629 |
| 24.599 | 0.06483 | 4996.8105 | 5088.9775 | 5182.3723 | 5277.1232 | 5372.1293 | 5467.0902 | 5562.0045 | 5656.4719 | 5751.6916 |
| 24.799 | 0.06534 | 5077.4447 | 5170.5936 | 5267.2587 | 5363.9795 | 5460.4953 | 5556.9832 | 5653.4604 | 5749.9043 | 5846.2919 |
| 24.999 | 0.06588 | 5154.4991 | 5254.0914 | 5353.1397 | 5451.3433 | 5549.5055 | 5647.6134 | 5745.6703 | 5843.6955 | 5941.6640 |
| 25.199 | 0.06641 | 5233.9022 | 5337.9708 | 5439.7152 | 5539.5144 | 5639.2679 | 5738.5740 | 5838.6342 | 5938.2435 | 6037.0077 |
| 25.399 | 0.06694 | 5326.0341 | 5425.3320 | 5526.9852 | 5629.3930 | 5729.7546 | 5831.0693 | 5932.3361 | 6033.5564 | 6134.7232 |
| 25.599 | 0.06746 | 5410.7547 | 5511.8749 | 5614.9498 | 5717.9790 | 5820.9616 | 5923.8969 | 6026.7840 | 6129.6224 | 6232.4104 |
| 25.799 | 0.06799 | 5494.1443 | 5598.8593 | 5707.6089 | 5808.2724 | 5912.8889 | 6017.4577 | 6121.9779 | 6226.4487 | 6330.8694 |
| 25.999 | 0.06852 | 5580.7025 | 5685.6054 | 5792.9625 | 5899.2731 | 6005.5364 | 6111.7515 | 6217.9177 | 6324.0342 | 6430.1030 |
| 26.199 | 0.06905 | 5664.4297 | 5774.4933 | 5883.0107 | 5990.9813 | 6098.4042 | 6206.7785 | 6314.6036 | 6422.3785 | 6530.1064 |
| 26.399 | 0.06957 | 5754.3757 | 5864.0620 | 5973.7535 | 6083.3969 | 6192.9922 | 6302.5387 | 6412.0354 | 6521.4816 | 6630.8764 |
| 26.599 | 0.07010 | 5847.3905 | 5951.8141 | 6065.1908 | 6174.5199 | 6287.8005 | 6399.0320 | 6510.2133 | 6621.3436 | 6732.4222 |
| 26.799 | 0.07063 | 5931.1241 | 6044.4670 | 6157.3226 | 6270.3503 | 6383.3291 | 6496.2584 | 6609.1371 | 6721.9645 | 6834.7397 |
| 26.999 | 0.07115 | 6020.5263 | 6135.3615 | 6250.1490 | 6364.8881 | 6479.5780 | 6594.2179 | 6708.8089 | 6823.3442 | 6937.8289 |
| 27.199 | 0.07168 | 6110.4970 | 6227.1578 | 6343.6699 | 6460.1333 | 6576.5471 | 6692.9106 | 6809.2227 | 6925.4828 | 7041.6898 |
| 27.399 | 0.07221 | 6201.3378 | 6319.6350 | 6437.8856 | 6556.0859 | 6674.2365 | 6792.3363 | 6910.3845 | 7028.3802 | 7146.3225 |
| 27.599 | 0.07274 | 6292.7469 | 6412.7954 | 6532.7954 | 6652.7459 | 6772.6462 | 6892.4953 | 7012.2923 | 7132.0365 | 7251.7268 |
| 27.799 | 0.07326 | 6384.8244 | 6506.6367 | 6628.3999 | 6750.1134 | 6871.7761 | 6993.3873 | 7114.9461 | 7236.4516 | 7357.9029 |
| 27.999 | 0.07379 | 6477.4711 | 6601.1597 | 6724.5990 | 6844.1852 | 6971.6263 | 7095.0125 | 7218.3459 | 7341.6256 | 7464.8507 |
| 28.199 | 0.07432 | 6570.9961 | 6695.3644 | 6821.6927 | 6946.9704 | 7072.1967 | 7197.3708 | 7322.4916 | 7447.5584 | 7572.5702 |
| 28.399 | 0.07484 | 6664.0705 | 6793.2507 | 6919.3808 | 7046.4601 | 7173.4875 | 7300.4622 | 7427.3834 | 7554.2501 | 7681.0614 |
| 28.599 | 0.07537 | 6759.0235 | 6884.4187 | 7017.7636 | 7146.6571 | 7275.4985 | 7404.2868 | 7533.0211 | 7661.7006 | 7790.3243 |
| 28.799 | 0.07590 | 6855.2453 | 6985.0585 | 7116.8408 | 7247.5615 | 7378.2297 | 7508.8445 | 7639.4049 | 7769.9100 | 7900.3589 |
| 28.999 | 0.07643 | 6951.3355 | 7081.4449 | 7214.6127 | 7349.1734 | 7481.6813 | 7614.1353 | 7746.5346 | 7878.8782 | 8011.1653 |
| 29.199 | 0.07695 | 7048.7954 | 7187.4129 | 7317.0790 | 7451.4927 | 7585.8531 | 7720.1593 | 7854.4103 | 7988.6054 | 8122.7434 |
| 29.399 | 0.07748 | 7145.5235 | 7281.4077 | 7418.2399 | 7554.5193 | 7690.7451 | 7826.9163 | 7963.0320 | 8099.0913 | 8235.0932 |
| 29.599 | 0.07801 | 7243.4207 | 7381.8841 | 7520.0953 | 7658.2534 | 7796.3574 | 7934.4065 | 8072.3997 | 8210.3361 | 8348.2147 |
| 29.799 | 0.07853 | 7342.3854 | 7482.5423 | 7622.6453 | 7762.6949 | 7902.6900 | 8042.6249 | 8182.5134 | 8322.3398 | 8462.1079 |
| 29.999 | 0.07906 | 7441.8213 | 7583.8821 | 7725.9899 | 7867.8438 | 8009.7429 | 8151.5864 | 8293.3731 | 8435.1023 | 8576.7728 |
| 30.199 | 0.07959 | 7541.0249 | 7685.9036 | 7829.8289 | 7973.7000 | 8117.5160 | 8261.2759 | 8404.9788 | 8548.6236 | 8692.2095 |
| 30.399 | 0.08011 | 7642.6977 | 7789.0067 | 7934.4625 | 8080.2637 | 8226.0054 | 8371.6967 | 8517.3304 | 8662.9038 | 8808.4178 |
| 30.599 | 0.08064 | 7744.1394 | 7891.9916 | 8039.7907 | 8187.5348 | 8335.2231 | 8482.8545 | 8630.4281 | 8777.9429 | 8925.3979 |
| 30.799 | 0.08117 | 7845.2484 | 7996.2581 | 8145.8134 | 8295.5134 | 8445.1571 | 8594.7435 | 8744.2717 | 8893.7408 | 9043.1497 |
| 30.999 | 0.08170 | 7949.0272 | 8100.8063 | 8252.5306 | 8404.1993 | 8555.8112 | 8707.3656 | 8858.8614 | 9010.2976 | 9161.6732 |
| 31.199 | 0.08222 | 8052.4769 | 8206.4362 | 8359.9424 | 8513.3926 | 8667.1857 | 8820.7208 | 8974.1970 | 9127.6132 | 9280.9684 |
| 31.399 | 0.08275 | 8156.5914 | 8312.3478 | 8468.0488 | 8623.6933 | 8779.2805 | 8934.8092 | 9090.2787 | 9245.6877 | 9401.0354 |
| 31.599 | 0.08328 | 8261.3767 | 8419.1411 | 8576.8496 | 8734.5014 | 8892.0954 | 9049.6307 | 9207.1062 | 9364.5210 | 9521.8740 |
| 31.799 | 0.08380 | 8366.8307 | 8526.6160 | 8686.3451 | 8846.0170 | 9005.6307 | 9165.1854 | 9324.6798 | 9484.1132 | 9643.4844 |
| 31.999 | 0.08433 | 8472.9537 | 8634.7726 | 8796.5350 | 8958.2399 | 9119.8863 | 9281.4731 | 9442.9994 | 9604.4643 | 9765.8664 |
| 32.199 | 0.08486 | 8579.7454 | 8741.6109 | 8907.4195 | 9071.1702 | 9234.8621 | 9398.4940 | 9562.0650 | 9725.5741 | 9889.0203 |
| 32.399 | 0.08539 | 8687.2361 | 8853.1329 | 9018.9986 | 9184.8080 | 9350.5581 | 9516.2481 | 9681.8766 | 9847.4429 | 10012.9457 |
| 32.599 | 0.08591 | 8795.3351 | 8961.1926 | 9131.2722 | 9299.1531 | 9466.9745 | 9634.7352 | 9802.4342 | 9970.0705 | 10137.6430 |
| 32.799 | 0.08644 | 8904.1336 | 9074.2160 | 9244.2403 | 9414.2057 | 9584.1111 | 9753.9555 | 9923.7378 | 10093.4569 | 10263.1119 |
| 32.999 | 0.08697 | 9017.4006 | 9185.7810 | 9357.9030 | 9529.9657 | 9701.9680 | 9873.9309 | 10045.7873 | 10217.6023 | 10389.3526 |
| 33.199 | 0.08749 | 9123.7364 | 9294.0277 | 9472.2602 | 9646.4331 | 9820.5451 | 9994.5956 | 10168.5828 | 10342.5064 | 10516.3650 |
| 33.399 | 0.08802 | 9234.5411 | 9410.4561 | 9587.3120 | 9763.6078 | 9939.8425 | 10116.0151 | 10292.1244 | 10468.1694 | 10644.1490 |
| 33.599 | 0.08855 | 9346.0146 | 9524.5662 | 9703.0583 | 9881.4900 | 10059.8602 | 10238.1679 | 10416.4119 | 10594.5913 | 10772.7048 |
| 33.799 | 0.08908 | 9458.1564 | 9639.8578 | 9819.4092 | 10000.0796 | 10180.5981 | 10361.0938 | 10541.4454 | 10721.7720 | 10902.0324 |
| 33.999 | 0.08960 | 9570.9683 | 9751.8314 | 9936.6340 | 10119.3766 | 10302.0564 | 10484.6729 | 10667.2249 | 10849.7116 | 11032.1316 |
| 34.199 | 0.09013 | 9684.4672 | 9869.4865 | 10054.4445 | 10239.3810 | 10424.2349 | 10609.0250 | 10793.7504 | 10978.4100 | 11163.0026 |
| 34.399 | 0.09066 | 9798.5967 | 9985.9233 | 10172.9890 | 10360.0920 | 10547.1336 | 10734.1104 | 10921.0219 | 11107.8673 | 11294.6452 |
| 34.599 | 0.09118 | 9913.4163 | 10102.8418 | 10292.2081 | 10481.5120 | 10670.7526 | 10859.9288 | 11049.0394 | 11238.0834 | 11427.0596 |
| 34.799 | 0.09171 | 10028.9207 | 10220.5420 | 10412.1216 | 10603.6386 | 10795.0919 | 10986.4804 | 11177.8029 | 11369.0584 | 11560.2457 |
| 34.999 | 0.09224 | 10144.7557 | 10334.9238 | 10537.7297 | 10726.4727 | 10920.1544 | 11113.7650 | 11307.3423 | 11500.7922 | 11694.2035 |
| 35.199 | 0.09277 | 10261.4803 | 10457.9873 | 10654.0324 | 10850.0141 | 11045.9313 | 11241.7829 | 11437.5678 | 11633.2849 | 11828.9330 |
| 35.399 | 0.09329 | 10379.7724 | 10577.7326 | 10775.0296 | 10974.2529 | 11172.4313 | 11370.5338 | 11568.5692 | 11766.5364 | 11964.4342 |
| 35.599 | 0.09382 | 10497.9345 | 10698.1594 | 10898.7214 | 11099.2191 | 11299.6517 | 11500.0179 | 11700.3167 | 11900.5468 | 12100.7072 |
| 35.799 | 0.09435 | 10614.3169 | 10819.2680 | 11022.1076 | 11224.8828 | 11427.5923 | 11630.2352 | 11832.8101 | 12035.3161 | 12237.7548 |
| 35.999 | 0.09487 | 10735.4663 | 10941.0503 | 11146.4885 | 11351.2538 | 11556.2532 | 11761.1855 | 11966.0495 | 12170.8442 | 12375.5682 |
| 36.199 | 0.09540 | 10855.0324 | 11061.5307 | 11270.9439 | 11478.3323 | 11685.6344 | 11892.8690 | 12100.0349 | 12307.1311 | 12514.1563 |
| 36.399 | 0.09593 | 10974.8604 | 11186.6830 | 11395.4338 | 11606.1142 | 11815.7358 | 12025.2856 | 12234.7663 | 12444.1769 | 12653.5161 |
| 36.599 | 0.09646 | 11094.5752 | 11317.5192 | 11522.5983 | 11734.6116 | 11946.5575 | 12158.4353 | 12370.2438 | 12581.9816 | 12793.6477 |
| 36.799 | 0.09698 | 11227.9409 | 11434.3361 | 11649.4573 | 11863.8121 | 12078.0994 | 12292.3162 | 12506.4671 | 12720.5454 | 12934.5509 |
| 36.999 | 0.09751 | 11347.3937 | 11560.2348 | 11777.0109 | 11993.7202 | 12210.3647 | 12426.9342 | 12643.4365 | 12859.8675 | 13076.2259 |
| 37.199 | 0.09804 | 11464.9394 | 11684.4454 | 11905.2499 | 12124.3356 | 12343.3442 | 12562.2833 | 12781.1519 | 12999.9487 | 13218.6726 |
| 37.399 | 0.09856 | 11591.4465 | 11812.4772 | 12034.2416 | 12255.6585 | 12477.0459 | 12698.3656 | 12919.6132 | 13140.7888 | 13361.8909 |
| 37.599 | 0.09909 | 11714.9361 | 11939.4209 | 12163.8388 | 12387.6098 | 12611.4499 | 12835.1809 | 13058.8226 | 13282.3877 | 13505.8840 |
| 37.799 | 0.09962 | 11841.4553 | 12067.8463 | 12294.1705 | 12520.4265 | 12746.6134 | 12972.7295 | 13198.7734 | 13424.7455 | 13650.6428 |
| 37.999 | 0.10014 | 11967.4426 | 12196.4514 | 12425.1968 | 12653.8716 | 12882.4760 | 13111.0111 | 13339.4733 | 13567.8621 | 13796.1764 |
| 38.199 | 0.10067 | 12094.4984 | 12379.7421 | 12556.9176 | 12788.0242 | 13019.0605 | 13250.0759 | 13480.9186 | 13711.7376 | 13942.4816 |
| 38.399 | 0.10120 | 12227.4124 | 12459.7125 | 12689.3330 | 12922.8840 | 13156.3667 | 13389.7730 | 13623.1099 | 13856.3720 | 14089.5586 |
| 38.599 | 0.10173 | 12355.7149 | 12590.3647 | 12822.4429 | 13058.4514 | 13294.2895 | 13530.2540 | 13766.0472 | 14001.7654 | 14237.4073 |
| 38.799 | 0.10225 | 12474.2824 | 12721.4945 | 12955.2473 | 13194.7254 | 13433.4337 | 13670.4640 | 13907.7305 | 14147.9172 | 14386.0277 |
| 38.999 | 0.10278 | 12604.6124 | 12863.7160 | 13097.7467 | 13331.7263 | 13572.5996 | 13813.4153 | 14053.1598 | 14294.9284 | 14535.4198 |
| 39.199 | 0.10331 | 12738.8122 | 12987.4111 | 13224.0398 | 13469.1978 | 13712.7938 | 13955.1957 | 14199.3351 | 14442.4979 | 14685.5836 |
| 39.399 | 0.10383 | 12866.4683 | 13118.7900 | 13361.4779 | 13607.7947 | 13853.6842 | 14099.5402 | 14345.2504 | 14590.9265 | 14836.5192 |
| 39.599 | 0.10436 | 13000.2220 | 13247.8575 | 13498.4105 | 13745.8991 | 13995.3149 | 14243.6569 | 14491.9236 | 14740.1139 | 14988.2264 |
| 39.799 | 0.10489 | 13133.4271 | 13386.5927 | 13635.1077 | 13886.7139 | 14137.6609 | 14388.5307 | 14639.3364 | 14890.0602 | 15140.7054 |
| 39.999 | 0.10542 | 13264.7026 | 13520.1466 | 13773.6594 | 14027.2300 | 14280.7272 | 14534.1467 | 14787.4961 | 15040.7654 | 15293.9561 |
| 40.199 | 0.10594 | 13394.4474 | 13650.1727 | 13917.3757 | 14168.4560 | 14424.5137 | 14680.4957 | 14936.4044 | 15192.2294 | 15447.9789 |
| 40.399 | 0.10647 | 13520.7603 | 13792.3395 | 14051.6865 | 14310.3905 | 14569.0204 | 14827.5749 | 15086.0546 | 15344.4523 | 15602.7726 |

## TABLE D.III

## Calculation of Flow Rates through Orifice Plate as a Function of Orifice Pressure Drop and Air Temperature and Static Upstream Pressure

( $\beta$= 0.6347)

| P1 | P2 | 60 DEG F | 70 DEG F | 80 DEG F | 90 DEG F | 100 DEG F | 110 DEG F | 120 DEG F | 130 DEG F | 140 DEG F |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.000 | 0.00000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.200 | 0.00052 | 0.0031 | 0.0031 | 0.0031 | 0.0031 | 0.0031 | 0.0031 | 0.0030 | 0.0030 | 0.0030 |
| 0.400 | 0.00105 | 0.0319 | 0.0321 | 0.0322 | 0.0323 | 0.0323 | 0.0324 | 0.0325 | 0.0325 | 0.0326 |
| 0.600 | 0.00158 | 0.1126 | 0.1133 | 0.1140 | 0.1146 | 0.1152 | 0.1158 | 0.1163 | 0.1167 | 0.1171 |
| 0.800 | 0.00210 | 0.2614 | 0.2640 | 0.2663 | 0.2680 | 0.2699 | 0.2716 | 0.2733 | 0.2749 | 0.2764 |
| 0.999 | 0.00263 | 0.4899 | 0.4946 | 0.4992 | 0.5035 | 0.5077 | 0.5117 | 0.5156 | 0.5193 | 0.5229 |
| 1.199 | 0.00316 | 0.8033 | 0.8119 | 0.8202 | 0.8282 | 0.8360 | 0.8436 | 0.8508 | 0.8579 | 0.8646 |
| 1.399 | 0.00369 | 1.2063 | 1.2202 | 1.2337 | 1.2468 | 1.2596 | 1.2721 | 1.2841 | 1.2959 | 1.3072 |
| 1.599 | 0.00421 | 1.7016 | 1.7226 | 1.7426 | 1.7625 | 1.7818 | 1.8006 | 1.8190 | 1.8369 | 1.8543 |
| 1.799 | 0.00474 | 2.2913 | 2.3206 | 2.3492 | 2.3773 | 2.4048 | 2.4317 | 2.4580 | 2.4836 | 2.5087 |
| 1.999 | 0.00527 | 2.9767 | 3.0142 | 3.0550 | 3.0931 | 3.1304 | 3.1670 | 3.2028 | 3.2379 | 3.2722 |
| 2.199 | 0.00579 | 3.7591 | 3.8105 | 3.8611 | 3.9109 | 3.9597 | 4.0077 | 4.0549 | 4.1010 | 4.1463 |
| 2.399 | 0.00632 | 4.6430 | 4.7062 | 4.7684 | 4.8316 | 4.8930 | 4.9549 | 5.0150 | 5.0740 | 5.1320 |
| 2.599 | 0.00685 | 5.6171 | 5.6979 | 5.7776 | 5.8560 | 5.9333 | 6.0094 | 6.0842 | 6.1576 | 6.2303 |
| 2.799 | 0.00737 | 6.6933 | 6.7922 | 6.8890 | 6.9846 | 7.0789 | 7.1716 | 7.2630 | 7.3531 | 7.4418 |
| 2.999 | 0.00790 | 7.8699 | 7.9873 | 8.1033 | 8.2177 | 8.3307 | 8.4421 | 8.5519 | 8.6603 | 8.7670 |
| 3.199 | 0.00843 | 9.1492 | 9.2837 | 9.4206 | 9.5558 | 9.6893 | 9.8212 | 9.9513 | 10.0797 | 10.2064 |
| 3.399 | 0.00896 | 10.5204 | 10.6816 | 10.8413 | 10.9991 | 11.1551 | 11.3092 | 11.4615 | 11.6118 | 11.7602 |
| 3.599 | 0.00948 | 11.9954 | 12.1811 | 12.3655 | 12.5479 | 12.7282 | 12.9065 | 13.0827 | 13.2566 | 13.4289 |
| 3.799 | 0.01001 | 13.5695 | 13.7826 | 13.9935 | 14.2022 | 14.4088 | 14.6131 | 14.8151 | 15.0150 | 15.2125 |
| 3.999 | 0.01054 | 15.2463 | 15.4860 | 15.7254 | 15.9624 | 16.1970 | 16.4292 | 16.6591 | 16.8864 | 17.1113 |
| 4.199 | 0.01106 | 17.0193 | 17.2918 | 17.5612 | 17.8284 | 18.0931 | 18.3551 | 18.6146 | 18.8714 | 19.1259 |
| 4.399 | 0.01159 | 18.8946 | 19.1993 | 19.5013 | 19.8005 | 20.0971 | 20.3908 | 20.6818 | 20.9697 | 21.2532 |
| 4.599 | 0.01212 | 20.6703 | 21.0093 | 21.3455 | 21.6787 | 22.0091 | 22.3364 | 22.6608 | 22.9824 | 23.3005 |
| 4.799 | 0.01265 | 22.9465 | 23.3218 | 23.6940 | 24.0632 | 24.4292 | 24.7921 | 25.1518 | 25.5083 | 25.8615 |
| 4.999 | 0.01317 | 25.1232 | 25.5367 | 25.9469 | 26.3538 | 26.7575 | 27.1578 | 27.5548 | 27.9483 | 28.3384 |
| 5.199 | 0.01370 | 27.4003 | 27.8540 | 28.3042 | 28.7509 | 29.1940 | 29.6337 | 30.0698 | 30.5023 | 30.9312 |
| 5.399 | 0.01423 | 29.7784 | 30.2740 | 30.7659 | 31.2543 | 31.7389 | 32.2196 | 32.6970 | 33.1703 | 33.6396 |
| 5.599 | 0.01475 | 32.2577 | 32.7965 | 33.3322 | 33.8641 | 34.3921 | 34.9162 | 35.4363 | 35.9525 | 36.4646 |
| 5.799 | 0.01528 | 34.8367 | 35.4216 | 36.0030 | 36.5834 | 37.1537 | 37.7229 | 38.2879 | 38.8488 | 39.4054 |
| 5.999 | 0.01581 | 37.5163 | 38.1494 | 38.7784 | 39.4032 | 40.0237 | 40.6399 | 41.2518 | 41.8593 | 42.4623 |
| 6.199 | 0.01634 | 40.2971 | 40.9799 | 41.6584 | 42.3325 | 43.0022 | 43.6674 | 44.3280 | 44.9846 | 45.6364 |
| 6.399 | 0.01686 | 43.1796 | 43.9131 | 44.6431 | 45.3684 | 46.0892 | 46.8052 | 47.5165 | 48.2230 | 48.9247 |
| 6.599 | 0.01739 | 46.1617 | 46.9490 | 47.7324 | 48.5110 | 49.2847 | 50.0535 | 50.8175 | 51.5764 | 52.3302 |
| 6.799 | 0.01792 | 49.2447 | 50.0877 | 50.9264 | 51.7601 | 52.5887 | 53.4123 | 54.2309 | 55.0446 | 55.8519 |
| 6.999 | 0.01844 | 52.4276 | 53.3292 | 54.2251 | 55.1158 | 56.0014 | 56.8816 | 57.7565 | 58.6260 | 59.4900 |
| 7.199 | 0.01897 | 55.7131 | 56.6734 | 57.6285 | 58.5782 | 59.5226 | 60.4614 | 61.3947 | 62.3223 | 63.2443 |
| 7.399 | 0.01950 | 59.0984 | 60.1225 | 61.1367 | 62.1473 | 63.1524 | 64.1517 | 65.1453 | 66.1331 | 67.1150 |
| 7.599 | 0.02002 | 62.5954 | 63.6753 | 64.7496 | 65.8231 | 66.8930 | 67.9526 | 69.0064 | 70.0543 | 71.1020 |
| 7.799 | 0.02055 | 66.1730 | 67.3230 | 68.4673 | 69.6055 | 70.7378 | 71.8640 | 72.9841 | 74.0979 | 75.2056 |
| 7.999 | 0.02108 | 69.8614 | 71.0788 | 72.2897 | 73.4947 | 74.6935 | 75.8860 | 77.0722 | 78.2519 | 79.4251 |
| 8.199 | 0.02161 | 73.6502 | 74.9370 | 76.2169 | 77.4906 | 78.7579 | 80.0187 | 81.2729 | 82.5204 | 83.7612 |
| 8.399 | 0.02213 | 77.5417 | 78.8982 | 80.2490 | 81.5932 | 82.9309 | 84.2619 | 85.5861 | 86.9034 | 88.2138 |
| 8.599 | 0.02266 | 81.5327 | 82.9623 | 84.3859 | 85.8026 | 87.2126 | 88.6157 | 90.0118 | 91.4009 | 92.7828 |
| 8.799 | 0.02319 | 85.6244 | 87.1293 | 88.6275 | 90.1187 | 91.6030 | 93.0821 | 94.5551 | 96.0126 | 97.4681 |
| 8.999 | 0.02371 | 89.8174 | 91.3992 | 92.9739 | 94.5416 | 96.1020 | 97.6552 | 99.2010 | 100.7393 | 102.2700 |
| 9.199 | 0.02424 | 94.1115 | 95.7720 | 97.4252 | 99.0712 | 100.7098 | 102.3409 | 103.9644 | 105.5822 | 107.1883 |
| 9.399 | 0.02477 | 98.5063 | 100.2476 | 101.9816 | 103.7076 | 105.4263 | 107.1373 | 108.8435 | 110.5357 | 112.2230 |
| 9.599 | 0.02530 | 103.0024 | 104.8262 | 106.6424 | 108.4509 | 110.2515 | 112.0443 | 113.8291 | 115.6057 | 117.3742 |
| 9.799 | 0.02582 | 107.5994 | 109.5077 | 111.4282 | 113.3038 | 115.1854 | 117.0620 | 118.9303 | 120.7953 | 122.6549 |
| 9.999 | 0.02635 | 112.2973 | 114.2920 | 116.2789 | 118.2576 | 120.2286 | 122.1803 | 124.1241 | 126.0594 | 127.9860 |
| 10.199 | 0.02688 | 117.0964 | 119.1793 | 121.2546 | 123.3211 | 125.3795 | 127.4253 | 129.4705 | 131.5030 | 133.5266 |
| 10.399 | 0.02740 | 121.9967 | 124.1696 | 126.3367 | 128.4915 | 130.6396 | 132.7790 | 134.9076 | 137.0314 | 139.1437 |
| 10.599 | 0.02793 | 126.9968 | 129.2627 | 131.5200 | 133.7686 | 136.0085 | 138.2394 | 140.4612 | 142.6740 | 144.8774 |
| 10.799 | 0.02846 | 132.0987 | 134.4588 | 136.8101 | 139.1526 | 141.4861 | 143.8134 | 146.1255 | 148.4313 | 150.7275 |
| 10.999 | 0.02898 | 137.2919 | 139.7578 | 142.2051 | 144.6433 | 147.0724 | 149.4922 | 151.9024 | 154.3036 | 156.6941 |
| 11.199 | 0.02951 | 142.6053 | 145.1597 | 147.7049 | 150.2409 | 152.7675 | 155.2846 | 157.7920 | 160.2896 | 162.7772 |
| 11.399 | 0.03004 | 148.0101 | 150.6646 | 153.3097 | 155.9453 | 158.5714 | 161.1877 | 163.7942 | 166.3906 | 168.9769 |
| 11.599 | 0.03057 | 153.5154 | 156.2724 | 159.0193 | 161.7566 | 164.4846 | 167.2015 | 169.9093 | 172.6062 | 175.2934 |
| 11.799 | 0.03109 | 159.1227 | 161.9831 | 164.8338 | 167.6746 | 170.5054 | 173.3261 | 176.1364 | 178.9364 | 181.7257 |
| 11.999 | 0.03162 | 164.8305 | 167.7968 | 170.7532 | 173.6995 | 176.6356 | 179.5613 | 182.4766 | 185.3812 | 188.2750 |
| 12.199 | 0.03215 | 170.6393 | 173.7134 | 176.7774 | 179.8312 | 182.8745 | 185.9072 | 188.9293 | 191.9405 | 194.9407 |
| 12.399 | 0.03268 | 176.5492 | 179.7330 | 182.9066 | 186.0697 | 189.2222 | 192.3639 | 195.4967 | 198.6145 | 201.7230 |
| 12.599 | 0.03320 | 182.5606 | 185.8556 | 189.1406 | 192.4150 | 195.6786 | 198.9313 | 202.1728 | 205.4030 | 208.6218 |
| 12.799 | 0.03373 | 188.6714 | 192.0810 | 195.4796 | 198.8672 | 202.2439 | 205.6093 | 208.9635 | 212.3051 | 215.6371 |
| 12.999 | 0.03425 | 194.8847 | 198.4095 | 201.9234 | 205.4262 | 208.9179 | 212.3981 | 215.8669 | 219.3239 | 222.7690 |
| 13.199 | 0.03478 | 201.1996 | 204.8409 | 208.4721 | 212.0921 | 215.7007 | 219.2977 | 222.8829 | 226.4562 | 230.0174 |
| 13.399 | 0.03531 | 207.6134 | 211.3752 | 215.1257 | 218.8648 | 222.5923 | 226.3079 | 230.0116 | 233.7031 | 237.3844 |
| 13.599 | 0.03583 | 214.1291 | 218.0125 | 221.8843 | 225.7444 | 229.5926 | 233.4289 | 237.2530 | 241.0647 | 244.8639 |
| 13.799 | 0.03636 | 220.7465 | 224.7628 | 228.7677 | 232.7567 | 236.7317 | 240.6906 | 244.6373 | 248.5608 | 252.4620 |
| 13.999 | 0.03689 | 227.4642 | 231.5940 | 235.7140 | 239.8240 | 243.9197 | 248.0030 | 252.0737 | 256.1316 | 260.1766 |
| 14.199 | 0.03742 | 234.2831 | 238.5422 | 242.7893 | 247.0240 | 251.2464 | 255.4561 | 259.6530 | 263.8370 | 268.0077 |
| 14.399 | 0.03794 | 241.2031 | 245.5914 | 249.9674 | 254.3313 | 258.6919 | 263.0200 | 267.3451 | 271.6570 | 275.9556 |
| 14.599 | 0.03847 | 248.2241 | 252.7435 | 257.2504 | 261.7447 | 266.2262 | 270.6946 | 275.1498 | 279.5916 | 284.0197 |
| 14.799 | 0.03900 | 255.3462 | 259.9986 | 264.6384 | 269.2653 | 273.8793 | 278.4799 | 283.0677 | 287.6408 | 292.2005 |
| 14.999 | 0.03952 | 262.5687 | 267.3567 | 272.1313 | 276.8928 | 281.6411 | 286.3760 | 291.0972 | 295.8046 | 300.4979 |
| 15.199 | 0.04005 | 269.8933 | 274.8177 | 279.7290 | 284.6271 | 289.5116 | 294.3828 | 299.2399 | 304.0836 | 308.9119 |
| 15.399 | 0.04058 | 277.3184 | 282.3817 | 287.4317 | 292.4683 | 297.4912 | 302.5003 | 307.4956 | 312.4751 | 317.4426 |
| 15.599 | 0.04111 | 284.8445 | 290.0486 | 295.2393 | 300.4163 | 305.5795 | 310.7266 | 315.8634 | 320.9838 | 326.0894 |
| 15.799 | 0.04164 | 292.4717 | 297.8186 | 303.1518 | 308.4712 | 313.7765 | 319.0676 | 324.3442 | 329.6051 | 334.8531 |
| 15.999 | 0.04216 | 300.1994 | 305.6919 | 311.1692 | 316.6329 | 322.0824 | 327.5174 | 332.9377 | 338.3430 | 343.7333 |
| 16.199 | 0.04269 | 308.0291 | 313.6673 | 319.2916 | 324.9015 | 330.4970 | 336.0779 | 341.6438 | 347.1940 | 352.7300 |
| 16.399 | 0.04322 | 315.9591 | 321.7462 | 327.5180 | 333.2770 | 339.0235 | 344.7451 | 350.4626 | 356.1608 | 361.8433 |
| 16.599 | 0.04374 | 323.9920 | 329.9290 | 335.8510 | 341.7583 | 347.6527 | 353.5311 | 359.3941 | 365.2416 | 371.0732 |
| 16.799 | 0.04427 | 332.1224 | 338.2128 | 344.2880 | 350.3484 | 356.3938 | 362.4236 | 368.4383 | 374.4370 | 380.4197 |
| 16.999 | 0.04480 | 340.3562 | 346.6005 | 352.8300 | 359.0445 | 365.2436 | 371.4272 | 377.5951 | 383.7476 | 389.8847 |
| 17.199 | 0.04532 | 348.6906 | 355.0913 | 361.4769 | 367.8473 | 374.2022 | 380.5414 | 386.8647 | 393.1717 | 399.4643 |
| 17.399 | 0.04585 | 357.1267 | 363.6853 | 370.2288 | 376.7571 | 383.2694 | 389.7664 | 396.2469 | 402.7113 | 409.1585 |
| 17.599 | 0.04638 | 365.6524 | 372.3817 | 379.0855 | 385.7737 | 392.4459 | 399.1021 | 405.7418 | 412.3653 | 418.9742 |
| 17.799 | 0.04691 | 374.2990 | 381.1813 | 388.0472 | 394.8972 | 401.7312 | 408.5485 | 415.3494 | 422.1335 | 428.9005 |
| 17.999 | 0.04743 | 383.0394 | 390.0840 | 397.1137 | 404.1274 | 411.1248 | 418.1057 | 425.0697 | 432.0167 | 438.9464 |
| 18.199 | 0.04796 | 391.8785 | 399.0890 | 406.2852 | 413.4640 | 420.6275 | 427.7736 | 434.9027 | 442.0146 | 449.1309 |
| 18.399 | 0.04849 | 400.8185 | 408.1982 | 415.5617 | 422.9087 | 430.2394 | 437.5543 | 444.8484 | 452.1274 | 459.3879 |

|  |  |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|
| 18.500 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 18.700 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 18.900 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 19.100 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 19.300 | 0.05117 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 19.500 | 0.05165 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 19.700 | 0.05218 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 19.900 | 0.05271 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 20.100 | 0.05323 | [illegible] | [illegible] | [illegible] | 512.7142 | 521.6305 | 530.5006 | 539.4306 | [illegible] | [illegible] |
| 20.300 | 0.05376 | 495.7017 | [illegible] | 514.0900 | 523.2267 | 532.3381 | 541.4363 | 550.5032 | [illegible] | [illegible] |
| 20.500 | 0.05428 | 505.0333 | 514.1896 | 524.5272 | 533.8462 | 543.1463 | 552.4272 | 561.6885 | [illegible] | 580.4543 |
| 20.700 | 0.05481 | 515.9001 | 525.3338 | 535.3627 | 544.5727 | 554.3035 | 563.2369 | 572.9465 | [illegible] | [illegible] |
| 20.900 | 0.05534 | 526.7636 | 535.9011 | 545.7031 | 555.4360 | 565.0095 | 574.7533 | 584.3972 | [illegible] | 603.0238 |
| 21.100 | 0.05587 | 536.5095 | 546.5316 | 556.4404 | 566.3461 | 576.2243 | 586.0025 | 595.9226 | 605.7361 | 615.5349 |
| 21.300 | 0.05640 | 547.2517 | 557.1060 | 567.2007 | 577.3932 | 587.4676 | 597.5425 | 607.5567 | 617.5751 | 627.3646 |
| 21.500 | 0.05692 | 557.4209 | 567.9410 | 578.2939 | 588.5471 | 598.8202 | 609.0731 | 619.3154 | 629.5100 | 639.7309 |
| 21.700 | 0.05745 | 568.7671 | 578.8333 | 589.3160 | 599.8270 | 610.2815 | 620.7346 | 631.1869 | 641.5701 | 651.9670 |
| 21.900 | 0.05798 | 579.0261 | 589.7026 | 600.4791 | 611.1755 | 621.8515 | 632.5306 | 643.1611 | 653.7546 | 664.3452 |
| 22.100 | 0.05851 | 589.8005 | 600.8270 | 611.7400 | 622.6500 | 633.5323 | 644.3890 | 655.2279 | 666.0465 | 676.8392 |
| 22.300 | 0.05903 | 600.9607 | 611.9960 | 623.1239 | 634.2317 | 645.3180 | 656.3835 | 667.4275 | 678.4447 | 689.4499 |
| 22.500 | 0.05956 | 611.9134 | 623.2672 | 634.5030 | 645.9196 | 657.2144 | 668.4879 | 679.7348 | 690.9696 | 702.1772 |
| 22.700 | 0.06008 | 623.3734 | 634.6416 | 646.1005 | 657.7147 | 669.2197 | 680.7032 | 692.1647 | 703.6004 | 715.0246 |
| 22.900 | 0.06061 | 634.3303 | 646.1106 | 657.8702 | 669.5167 | 681.3338 | 693.0261 | 704.7026 | 716.3532 | 727.9812 |
| 23.100 | 0.06114 | 645.7039 | 657.6990 | 669.6728 | 681.6255 | 693.5567 | 705.4654 | 717.3527 | 729.2169 | 741.0501 |
| 23.300 | 0.06167 | 657.1734 | 669.3019 | 681.5723 | 693.7413 | 705.8884 | 718.0134 | 730.1158 | 742.1953 | 754.2317 |
| 23.500 | 0.06219 | 668.7374 | 681.1001 | 693.5708 | 705.9639 | 718.3289 | 730.6716 | 742.9915 | 755.2884 | 767.5218 |
| 23.700 | 0.06272 | 680.4206 | 693.0072 | 705.6062 | 718.2936 | 730.8783 | 743.4426 | 755.9833 | 768.4961 | 780.9085 |
| 23.900 | 0.06325 | 692.1767 | 705.0693 | 717.8009 | 730.7297 | 743.5364 | 756.3234 | 769.0811 | 781.8184 | 794.5318 |
| 24.100 | 0.06377 | 704.0474 | 717.1444 | 730.2198 | 743.2720 | 756.3034 | 769.3140 | 782.2905 | 795.2554 | 808.1917 |
| 24.300 | 0.06430 | 716.0109 | 729.3424 | 742.6446 | 755.9233 | 769.1792 | 782.4121 | 795.6215 | 808.8079 | 821.9661 |
| 24.500 | 0.06483 | 728.0916 | 741.6435 | 755.1731 | 768.6799 | 782.1638 | 795.6262 | 809.0605 | 822.4733 | 835.8612 |
| 24.700 | 0.06536 | 740.2654 | 754.0475 | 767.8371 | 781.5438 | 795.2572 | 808.9476 | 822.6127 | 836.2542 | 849.8758 |
| 24.900 | 0.06588 | 752.5403 | 766.5946 | 780.5461 | 794.5149 | 808.4596 | 822.3803 | 836.2774 | 850.1497 | 864.0076 |
| 25.100 | 0.06641 | 764.9163 | 779.1646 | 793.3809 | 807.5920 | 821.7706 | 835.9260 | 850.0548 | 864.1599 | 878.2300 |
| 25.300 | 0.06694 | 777.3932 | 791.8776 | 806.3300 | 820.7765 | 835.1903 | 849.5739 | 863.9448 | 878.2847 | 892.5002 |
| 25.500 | 0.06746 | 789.9713 | 804.6936 | 819.3925 | 834.0679 | 848.7190 | 863.3457 | 877.9476 | 892.5242 | 907.0792 |
| 25.700 | 0.06799 | 802.6903 | 817.6125 | 832.5912 | 847.4660 | 862.3565 | 877.2223 | 892.0630 | 906.8783 | 921.6677 |
| 25.900 | 0.06852 | 815.4305 | 830.6345 | 845.9140 | 860.9713 | 876.1028 | 891.2096 | 906.2912 | 921.3471 | 936.3764 |
| 26.100 | 0.06905 | 828.3116 | 843.7594 | 859.3034 | 874.5830 | 889.9579 | 905.3977 | 920.6322 | 935.9305 | 951.2326 |
| 26.300 | 0.06957 | 841.2938 | 856.9876 | 872.8500 | 888.3018 | 903.9218 | 919.5165 | 935.0856 | 950.6205 | 966.1449 |
| 26.500 | 0.07010 | 854.3771 | 870.3183 | 886.2352 | 902.1276 | 917.9945 | 933.8362 | 949.6519 | 965.4412 | 981.2039 |
| 26.700 | 0.07063 | 867.5614 | 883.7522 | 899.9100 | 916.0600 | 932.1761 | 948.2665 | 964.3336 | 980.3686 | 996.3746 |
| 26.900 | 0.07115 | 880.8467 | 897.2891 | 913.7060 | 930.0996 | 946.4665 | 962.8077 | 979.1229 | 995.4109 | 1011.6716 |
| 27.100 | 0.07168 | 894.2331 | 910.9290 | 927.6000 | 944.2457 | 960.8657 | 977.4595 | 994.0288 | 1010.5674 | 1027.0801 |
| 27.300 | 0.07221 | 907.7205 | 924.6710 | 941.5881 | 958.4989 | 975.3737 | 992.2222 | 1009.0639 | 1025.8385 | 1042.6056 |
| 27.500 | 0.07274 | 921.3089 | 938.5177 | 955.7012 | 972.8589 | 989.9905 | 1007.0958 | 1024.1737 | 1041.2244 | 1058.2472 |
| 27.700 | 0.07326 | 934.9983 | 952.4006 | 969.9092 | 987.3258 | 1004.7162 | 1022.0780 | 1039.4162 | 1056.7249 | 1074.0057 |
| 27.900 | 0.07379 | 948.7887 | 966.5106 | 984.2221 | 1001.8995 | 1019.5506 | 1037.1747 | 1054.7743 | 1072.3401 | 1089.8807 |
| 28.100 | 0.07432 | 962.6802 | 980.6732 | 998.6399 | 1016.5803 | 1034.4939 | 1052.3804 | 1070.2392 | 1088.0700 | 1105.8723 |
| 28.300 | 0.07484 | 976.6733 | 994.9310 | 1013.1627 | 1031.3678 | 1049.5406 | 1067.6960 | 1085.8190 | 1103.9145 | 1121.9805 |
| 28.500 | 0.07537 | 990.7669 | 1009.2918 | 1027.7904 | 1046.2622 | 1064.7069 | 1083.1262 | 1101.5131 | 1119.8737 | 1138.2053 |
| 28.700 | 0.07590 | 1004.9617 | 1023.7556 | 1042.5230 | 1061.2635 | 1079.9766 | 1098.6620 | 1117.3181 | 1135.9474 | 1154.5467 |
| 28.900 | 0.07643 | 1019.2575 | 1038.3224 | 1057.3606 | 1076.3717 | 1095.3552 | 1114.3137 | 1133.2376 | 1152.1359 | 1171.0046 |
| 29.100 | 0.07695 | 1033.6543 | 1052.9921 | 1072.3031 | 1091.5867 | 1110.8426 | 1130.0702 | 1149.2692 | 1168.4389 | 1187.5792 |
| 29.300 | 0.07748 | 1048.1522 | 1067.7649 | 1087.3505 | 1106.9086 | 1126.4387 | 1145.9468 | 1165.4132 | 1184.8567 | 1204.2704 |
| 29.500 | 0.07801 | 1062.7511 | 1082.6436 | 1102.5029 | 1122.3374 | 1142.1437 | 1161.9216 | 1181.6730 | 1201.3891 | 1221.0784 |
| 29.700 | 0.07853 | 1077.4510 | 1097.6193 | 1117.7602 | 1137.8731 | 1157.9576 | 1178.0132 | 1198.0395 | 1218.0364 | 1238.0026 |
| 29.900 | 0.07906 | 1092.2520 | 1112.7011 | 1133.1224 | 1153.5156 | 1173.8802 | 1194.2197 | 1214.5218 | 1234.7978 | 1255.0433 |
| 30.100 | 0.07959 | 1107.1541 | 1127.8850 | 1148.5895 | 1169.2650 | 1189.9116 | 1210.5290 | 1231.1167 | 1251.6741 | 1272.2036 |
| 30.300 | 0.08011 | 1122.1572 | 1143.1736 | 1164.1615 | 1185.1213 | 1206.0519 | 1226.9334 | 1247.8263 | 1268.6651 | 1289.4760 |
| 30.500 | 0.08064 | 1137.2613 | 1158.5641 | 1179.8386 | 1201.0844 | 1222.3010 | 1243.4870 | 1264.6444 | 1285.7707 | 1306.8656 |
| 30.700 | 0.08117 | 1152.4665 | 1174.0578 | 1195.6206 | 1217.1545 | 1238.6589 | 1260.1336 | 1281.5776 | 1302.9909 | 1324.3729 |
| 30.900 | 0.08170 | 1167.7727 | 1189.6544 | 1211.5075 | 1233.3314 | 1255.1256 | 1276.8898 | 1298.6233 | 1320.3258 | 1341.9968 |
| 31.100 | 0.08222 | 1183.1800 | 1205.3541 | 1227.4993 | 1249.6151 | 1271.7011 | 1293.7509 | 1315.7848 | 1337.7754 | 1359.7372 |
| 31.300 | 0.08275 | 1198.6883 | 1221.1567 | 1243.5960 | 1266.0058 | 1288.3855 | 1310.7347 | 1333.0529 | 1355.3396 | 1377.5963 |
| 31.500 | 0.08328 | 1214.2977 | 1237.0626 | 1259.7977 | 1282.5033 | 1305.1787 | 1327.8233 | 1350.4307 | 1373.0186 | 1395.5679 |
| 31.700 | 0.08380 | 1230.0081 | 1253.0710 | 1276.1043 | 1299.1077 | 1322.0807 | 1345.0227 | 1367.9333 | 1390.8119 | 1413.6581 |
| 31.900 | 0.08433 | 1245.8196 | 1269.1826 | 1292.5159 | 1315.8190 | 1339.0915 | 1362.3328 | 1385.5429 | 1408.7204 | 1431.8649 |
| 32.100 | 0.08486 | 1261.7321 | 1285.3972 | 1309.0323 | 1332.6372 | 1356.2111 | 1379.7937 | 1403.2645 | 1426.7429 | 1450.1883 |
| 32.300 | 0.08539 | 1277.7457 | 1301.7147 | 1325.6537 | 1349.5622 | 1373.4396 | 1397.2856 | 1421.0981 | 1444.8803 | 1468.6283 |
| 32.500 | 0.08591 | 1293.8603 | 1318.1353 | 1342.3801 | 1366.5941 | 1390.7768 | 1414.9270 | 1439.0485 | 1463.1326 | 1487.1849 |
| 32.700 | 0.08644 | 1310.0759 | 1334.6588 | 1359.2113 | 1383.7329 | 1408.2229 | 1432.6810 | 1457.1006 | 1481.4991 | 1505.8581 |
| 32.900 | 0.08697 | 1326.3926 | 1351.2854 | 1376.1475 | 1400.9785 | 1425.7778 | 1450.5449 | 1475.2793 | 1499.9805 | 1524.6479 |
| 33.100 | 0.08749 | 1342.8103 | 1368.0149 | 1393.1887 | 1418.3310 | 1443.4415 | 1468.5196 | 1493.5668 | 1518.5765 | 1543.5542 |
| 33.300 | 0.08802 | 1359.3291 | 1384.8475 | 1410.3347 | 1435.7904 | 1461.2141 | 1486.6051 | 1511.9630 | 1537.2872 | 1562.5772 |
| 33.500 | 0.08855 | 1375.9489 | 1401.7830 | 1427.5857 | 1453.3567 | 1479.0954 | 1504.8013 | 1530.4739 | 1556.1125 | 1581.7167 |
| 33.700 | 0.08908 | 1392.6697 | 1418.8215 | 1444.9417 | 1471.0299 | 1497.0856 | 1523.1083 | 1549.0976 | 1575.0525 | 1600.9729 |
| 33.900 | 0.08960 | 1409.4917 | 1435.9630 | 1462.4025 | 1488.8099 | 1515.1846 | 1541.5261 | 1567.8337 | 1594.1071 | 1620.3456 |
| 34.100 | 0.09013 | 1426.4147 | 1453.2076 | 1479.9683 | 1506.6968 | 1533.3924 | 1560.0546 | 1586.6827 | 1613.2764 | 1639.8349 |
| 34.300 | 0.09066 | 1443.4387 | 1470.5549 | 1497.6390 | 1524.6906 | 1551.7091 | 1578.6938 | 1605.6446 | 1632.5603 | 1659.4408 |
| 34.500 | 0.09118 | 1460.5638 | 1488.0054 | 1515.4147 | 1542.7913 | 1570.1345 | 1597.4439 | 1624.7188 | 1651.9588 | 1679.1633 |
| 34.700 | 0.09171 | 1477.7899 | 1505.5588 | 1533.2953 | 1560.9988 | 1588.6688 | 1616.3047 | 1643.9059 | 1671.4720 | 1699.0024 |
| 34.900 | 0.09224 | 1495.1171 | 1523.2153 | 1551.2808 | 1579.3132 | 1607.3119 | 1635.2762 | 1663.2058 | 1691.0999 | 1718.9581 |
| 35.100 | 0.09277 | 1512.5452 | 1540.9747 | 1569.3713 | 1597.7345 | 1626.0638 | 1654.3586 | 1682.6183 | 1710.8424 | 1739.0303 |
| 35.300 | 0.09329 | 1530.0745 | 1558.8371 | 1587.5667 | 1616.2627 | 1644.9245 | 1673.5516 | 1702.1439 | 1730.6996 | 1759.2192 |
| 35.500 | 0.09382 | 1547.7048 | 1576.8025 | 1605.8670 | 1634.8977 | 1663.8940 | 1692.8555 | 1721.7816 | 1750.6714 | 1779.5246 |
| 35.700 | 0.09435 | 1565.4361 | 1594.8709 | 1624.2723 | 1653.6396 | 1682.9724 | 1712.2701 | 1741.5321 | 1770.7578 | 1799.9467 |
| 35.900 | 0.09487 | 1583.2685 | 1613.0423 | 1642.7824 | 1672.4884 | 1702.1596 | 1731.7955 | 1761.3954 | 1790.9589 | 1820.4853 |
| 36.100 | 0.09540 | 1601.2019 | 1631.3167 | 1661.3976 | 1691.4441 | 1721.4556 | 1751.4316 | 1781.3715 | 1811.2747 | 1841.1405 |
| 36.300 | 0.09593 | 1619.2364 | 1649.6940 | 1680.1176 | 1710.5066 | 1740.8604 | 1771.1785 | 1801.4602 | 1831.7051 | 1861.9124 |
| 36.500 | 0.09646 | 1637.3719 | 1668.1744 | 1698.9426 | 1729.6760 | 1760.3741 | 1791.0361 | 1821.6617 | 1852.2501 | 1882.8008 |
| 36.700 | 0.09698 | 1655.6085 | 1686.7577 | 1717.8725 | 1748.9523 | 1779.9965 | 1811.0046 | 1841.9758 | 1872.9098 | 1903.8058 |
| 36.900 | 0.09751 | 1673.9461 | 1705.4441 | 1736.9074 | 1768.3355 | 1799.7278 | 1831.0837 | 1862.4027 | 1893.6841 | 1924.9274 |
| 37.100 | 0.09804 | 1692.3848 | 1724.2334 | 1756.0472 | 1787.8255 | 1819.5679 | 1851.2737 | 1882.9423 | 1914.5731 | 1946.1655 |
| 37.300 | 0.09856 | 1710.9245 | 1743.1257 | 1775.2919 | 1807.4224 | 1839.5168 | 1871.5744 | 1903.5946 | 1935.5768 | 1967.5203 |
| 37.500 | 0.09909 | 1729.5653 | 1762.1210 | 1794.6415 | 1827.1262 | 1859.5745 | 1891.9859 | 1924.3596 | 1956.6950 | 1988.9917 |
| 37.700 | 0.09962 | 1748.3071 | 1781.2193 | 1814.0961 | 1846.9369 | 1879.7411 | 1912.5084 | 1945.2373 | 1977.9280 | 2010.5797 |
| 37.900 | 0.10014 | 1767.1499 | 1800.4206 | 1833.6556 | 1866.8545 | 1900.0165 | 1933.1411 | 1966.2277 | 1999.2756 | 2032.2842 |
| 38.100 | 0.10067 | 1786.0938 | 1819.7249 | 1853.3201 | 1886.8789 | 1920.4007 | 1953.8848 | 1987.3308 | 2020.7378 | 2054.1054 |
| 38.300 | 0.10120 | 1805.1388 | 1839.1321 | 1873.0895 | 1907.0102 | 1940.8937 | 1974.7394 | 2008.5466 | 2042.3147 | 2076.0431 |
| 38.500 | 0.10173 | 1824.2848 | 1858.6424 | 1892.9638 | 1927.2484 | 1961.4955 | 1995.7046 | 2029.8751 | 2064.0062 | 2098.0974 |
| 38.700 | 0.10225 | 1843.5318 | 1878.2556 | 1912.9431 | 1947.5934 | 1982.2062 | 2016.7807 | 2051.3163 | 2085.8124 | 2120.2683 |
| 38.900 | 0.10278 | 1862.8799 | 1897.9719 | 1933.0272 | 1968.0454 | 2003.0257 | 2037.9675 | 2072.8702 | 2107.7332 | 2142.5559 |
| 39.100 | 0.10331 | 1882.3290 | 1917.7911 | 1953.2164 | 1988.6042 | 2023.9540 | 2059.2651 | 2094.5369 | 2129.7687 | 2164.9600 |
| 39.300 | 0.10383 | 1901.8792 | 1937.7133 | 1973.5104 | 2009.2699 | 2044.9911 | 2080.6736 | 2116.3162 | 2151.9188 | 2187.4807 |
| 39.500 | 0.10436 | 1921.5304 | 1957.7385 | 1993.9095 | 2030.0426 | 2066.1370 | 2102.1929 | 2138.2082 | 2174.1836 | 2210.1179 |
| 39.700 | 0.10489 | 1941.2827 | 1977.8667 | 2014.4133 | 2050.9219 | 2087.3918 | 2123.8224 | 2160.2130 | 2196.5630 | 2232.8718 |
| 39.900 | 0.10542 | 1961.1360 | 1998.0979 | 2035.0222 | 2071.9082 | 2108.7553 | 2145.5630 | 2182.3304 | 2219.0571 | 2255.7423 |
| 40.100 | 0.10594 | 1981.0904 | 2018.4321 | 2055.7360 | 2093.0014 | 2130.2277 | 2167.4144 | 2204.5606 | 2241.6658 | 2278.7294 |
|  | 0.10647 | 2001.1458 | 2038.8693 | 2076.5467 | 2114.2016 | 2151.8089 | 2189.3765 | 2226.9035 | 2264.3892 | 2301.8330 |

|  |  |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|
| 40.599 | 0.10700 | 2021.3021 | 2059.4296 | 2097.4763 | 2135.5294 | 2173.496 | 2211.4444 | 2249.3597 | 2287.2272 | 2325.0533 |
| 40.799 | 0.10752 | 2041.4954 | 2080.2526 | 2119.0769 | 2154.9222 | 2194.2478 | 2233.4331 | 2271.4273 | 2310.1759 | 2348.3921 |
| 40.999 | 0.10805 | 2061.0184 | 2100.7087 | 2139.6420 | 2178.4429 | 2217.2155 | 2255.3275 | 2294.6043 | 2333.2474 | 2371.4835 |
| 41.199 | 0.10858 | 2082.3781 | 2121.6478 | 2160.4785 | 2200.2705 | 2239.2220 | 2278.3327 | 2317.4040 | 2356.4494 | 2395.4136 |
| 41.399 | 0.10911 | 2102.0394 | 2142.4300 | 2182.2223 | 2221.9249 | 2261.3473 | 2300.9487 | 2340.3304 | 2379.7250 | 2419.1002 |
| 41.599 | 0.10963 | 2123.4333 | 2163.6551 | 2203.0706 | 2243.6463 | 2283.5814 | 2323.4754 | 2363.3275 | 2403.1371 | 2442.9034 |
| 41.799 | 0.11016 | 2144.7631 | 2184.8132 | 2224.2238 | 2265.5945 | 2305.9244 | 2346.2129 | 2386.4593 | 2426.6630 | 2466.8232 |
| 41.999 | 0.11069 | 2165.2264 | 2206.0743 | 2246.9820 | 2287.6495 | 2328.3761 | 2369.0611 | 2409.7036 | 2450.3036 | 2490.8596 |
| 42.199 | 0.11121 | 2186.1017 | 2227.4303 | 2268.6452 | 2309.8115 | 2350.9367 | 2392.0224 | 2433.0611 | 2474.1588 | 2515.0426 |
| 42.399 | 0.11174 | 2207.2574 | 2249.9056 | 2290.5132 | 2332.3803 | 2373.6362 | 2415.6399 | 2456.9313 | 2497.9287 | 2539.2822 |
| 42.599 | 0.11227 | 2228.4265 | 2270.4755 | 2312.4862 | 2354.4561 | 2396.3844 | 2438.2705 | 2480.1136 | 2521.9138 | 2563.6684 |
| 42.799 | 0.11280 | 2249.6925 | 2292.1485 | 2334.5641 | 2376.9386 | 2419.2714 | 2461.5618 | 2503.8090 | 2546.0128 | 2588.1741 |
| 42.999 | 0.11332 | 2271.0615 | 2313.9246 | 2356.7470 | 2399.5281 | 2442.2473 | 2484.9638 | 2527.6170 | 2570.2264 | 2612.7965 |
| 43.199 | 0.11385 | 2292.5316 | 2335.9036 | 2378.9368 | 2422.2245 | 2465.3727 | 2508.4767 | 2551.5378 | 2594.5546 | 2637.5254 |
| 43.399 | 0.11438 | 2314.1027 | 2357.7856 | 2401.4275 | 2445.0277 | 2488.5855 | 2532.1303 | 2575.5712 | 2618.9977 | 2662.3790 |
| 43.599 | 0.11490 | 2335.7744 | 2379.8706 | 2423.9251 | 2467.9378 | 2511.9078 | 2555.9346 | 2599.7176 | 2643.5555 | 2687.3481 |
| 43.799 | 0.11543 | 2357.5481 | 2402.0588 | 2446.5277 | 2490.9547 | 2535.3360 | 2579.6797 | 2623.9763 | 2668.2279 | 2712.4339 |
| 43.999 | 0.11596 | 2379.4224 | 2424.3496 | 2469.2353 | 2514.0786 | 2558.8790 | 2603.6356 | 2648.3475 | 2693.0150 | 2737.6362 |
| 44.199 | 0.11649 | 2401.3977 | 2446.7436 | 2492.0477 | 2537.3093 | 2582.9277 | 2627.7023 | 2672.4321 | 2717.4167 | 2762.4951 |
| 44.399 | 0.11701 | 2423.4761 | 2469.2426 | 2514.9651 | 2560.6469 | 2606.2954 | 2651.8797 | 2697.4241 | 2742.9330 | 2788.3906 |
| 44.599 | 0.11754 | 2445.6515 | 2491.8406 | 2537.9874 | 2584.0914 | 2630.1518 | 2676.1678 | 2722.1388 | 2768.0641 | 2813.9427 |
| 44.799 | 0.11807 | 2467.9303 | 2514.5435 | 2561.1147 | 2607.6429 | 2654.1270 | 2700.5608 | 2746.9612 | 2793.3047 | 2839.6114 |
| 44.999 | 0.11859 | 2490.3095 | 2537.3495 | 2584.3469 | 2631.3010 | 2678.2111 | 2725.0765 | 2771.8964 | 2818.6730 | 2865.3967 |
| 45.199 | 0.11912 | 2512.7901 | 2560.2586 | 2607.6840 | 2655.0661 | 2702.4040 | 2749.6959 | 2796.9442 | 2844.1450 | 2891.2906 |
| 45.399 | 0.11965 | 2535.3716 | 2583.2703 | 2631.1261 | 2678.9381 | 2726.7057 | 2774.4282 | 2822.1047 | 2869.7346 | 2917.3170 |
| 45.599 | 0.12017 | 2558.0543 | 2606.3053 | 2654.6731 | 2702.9170 | 2751.1163 | 2799.2702 | 2847.3779 | 2895.4389 | 2943.4521 |
| 45.799 | 0.12070 | 2580.8380 | 2629.6032 | 2678.3250 | 2727.0027 | 2775.6356 | 2824.2229 | 2872.7639 | 2921.4578 | 2969.7038 |
| 45.999 | 0.12123 | 2603.7227 | 2652.9241 | 2702.0819 | 2751.1953 | 2800.2638 | 2849.2866 | 2898.2625 | 2947.1913 | 2996.0726 |
| 46.199 | 0.12176 | 2626.7085 | 2676.3469 | 2725.9437 | 2775.4948 | 2825.0038 | 2874.4607 | 2923.8739 | 2973.2395 | 3022.5569 |
| 46.399 | 0.12228 | 2649.7953 | 2699.8748 | 2749.9154 | 2799.9312 | 2849.8466 | 2899.7457 | 2949.5974 | 2999.4024 | 3049.1583 |
| 46.599 | 0.12281 | 2672.8832 | 2723.5047 | 2773.9820 | 2824.4145 | 2874.8012 | 2925.1415 | 2975.4347 | 3025.6799 | 3075.8763 |
| 46.799 | 0.12334 | 2696.2721 | 2747.2376 | 2798.1586 | 2849.0346 | 2899.8547 | 2950.6481 | 3001.3842 | 3052.0721 | 3102.7110 |
| 46.999 | 0.12386 | 2719.6621 | 2771.0736 | 2822.4402 | 2873.7616 | 2925.0369 | 2976.2655 | 3027.4464 | 3078.5789 | 3129.6622 |
| 47.199 | 0.12439 | 2743.1532 | 2795.0123 | 2846.8266 | 2898.5955 | 2950.3181 | 3001.9936 | 3053.6212 | 3105.2003 | 3156.7300 |
| 47.399 | 0.12492 | 2766.7452 | 2819.0561 | 2871.3180 | 2923.5362 | 2975.7080 | 3027.8324 | 3079.9088 | 3131.9364 | 3183.9144 |
| 47.599 | 0.12545 | 2790.4384 | 2843.1990 | 2895.9144 | 2948.5839 | 3001.2067 | 3053.7820 | 3106.3091 | 3158.7872 | 3211.2194 |
| 47.799 | 0.12597 | 2814.2325 | 2867.4468 | 2920.6156 | 2973.7384 | 3026.8142 | 3079.8424 | 3132.8221 | 3185.7526 | 3238.6340 |
| 47.999 | 0.12650 | 2838.1277 | 2891.7976 | 2945.4219 | 2998.9998 | 3052.5306 | 3106.0136 | 3159.4479 | 3212.8327 | 3266.1672 |
| 48.199 | 0.12703 | 2862.1240 | 2916.2514 | 2970.3330 | 3024.3681 | 3078.3558 | 3132.2955 | 3186.1863 | 3240.0274 | 3293.8179 |
| 48.399 | 0.12755 | 2886.7213 | 2940.8082 | 2995.3491 | 3049.8432 | 3104.2898 | 3158.6882 | 3213.0374 | 3267.3367 | 3321.5853 |
| 48.599 | 0.12808 | 2910.4197 | 2965.4680 | 3020.4701 | 3075.4252 | 3130.3327 | 3185.1916 | 3240.0012 | 3294.7607 | 3349.4693 |
| 48.799 | 0.12861 | 2934.7191 | 2990.2307 | 3045.6960 | 3101.1141 | 3156.4843 | 3211.9058 | 3267.0778 | 3322.2994 | 3377.4698 |
| 48.999 | 0.12914 | 2959.1196 | 3015.0965 | 3071.0269 | 3126.9099 | 3182.7448 | 3238.5308 | 3294.2670 | 3349.9527 | 3405.5870 |
| 49.199 | 0.12966 | 2983.6211 | 3040.0652 | 3096.4627 | 3152.8126 | 3209.1141 | 3265.3565 | 3321.5593 | 3377.7207 | 3433.8207 |
| 49.399 | 0.13019 | 3008.2236 | 3065.1370 | 3122.0034 | 3178.8221 | 3235.5922 | 3292.3130 | 3348.9836 | 3405.6033 | 3462.1711 |
| 49.599 | 0.13072 | 3032.9272 | 3090.3117 | 3147.6491 | 3204.9385 | 3262.1792 | 3319.3703 | 3376.5110 | 3433.6005 | 3490.6380 |
| 49.799 | 0.13124 | 3057.7319 | 3115.5895 | 3173.3997 | 3231.1618 | 3288.8749 | 3346.5383 | 3404.1511 | 3461.7124 | 3519.2215 |
| 49.999 | 0.13177 | 3082.6376 | 3140.9702 | 3199.2553 | 3257.4920 | 3315.6795 | 3373.8171 | 3431.9039 | 3489.9390 | 3547.9216 |
| 50.199 | 0.13230 | 3107.6443 | 3166.4539 | 3225.2157 | 3283.9290 | 3342.5929 | 3401.2066 | 3459.7693 | 3518.2502 | 3576.7303 |
| 50.399 | 0.13283 | 3132.7521 | 3192.0406 | 3251.2811 | 3310.4729 | 3369.6151 | 3428.7070 | 3487.7475 | 3546.7361 | 3605.6716 |
| 50.599 | 0.13335 | 3157.9607 | 3217.7303 | 3277.4515 | 3337.1237 | 3396.7462 | 3456.3180 | 3515.8384 | 3575.3066 | 3634.7215 |
| 50.799 | 0.13388 | 3183.2709 | 3243.5230 | 3303.7268 | 3363.8914 | 3423.9960 | 3484.0399 | 3544.0421 | 3603.9917 | 3663.8880 |
| 50.999 | 0.13441 | 3208.6817 | 3269.4186 | 3330.1070 | 3390.7459 | 3451.3347 | 3511.8725 | 3572.3584 | 3632.7915 | 3693.1711 |
| 51.199 | 0.13493 | 3234.1937 | 3295.4173 | 3356.5921 | 3417.7174 | 3478.7922 | 3539.8159 | 3600.7874 | 3661.7060 | 3722.5708 |
| 51.399 | 0.13546 | 3259.8068 | 3321.5190 | 3383.1822 | 3444.7957 | 3506.3585 | 3567.8700 | 3629.3291 | 3690.7351 | 3752.0870 |
| 51.599 | 0.13599 | 3285.5208 | 3347.7236 | 3409.8772 | 3471.9809 | 3534.0337 | 3596.0349 | 3657.9836 | 3719.8789 | 3781.7199 |
| 51.799 | 0.13652 | 3311.3360 | 3374.0312 | 3436.6772 | 3499.2729 | 3561.8177 | 3624.3105 | 3686.7507 | 3749.1373 | 3811.4693 |
| 51.999 | 0.13704 | 3337.2521 | 3400.4419 | 3463.5821 | 3526.6719 | 3589.7104 | 3652.6970 | 3715.6306 | 3778.5103 | 3841.3354 |
| 52.199 | 0.13757 | 3363.2694 | 3426.9555 | 3490.5919 | 3554.1777 | 3617.7121 | 3681.1942 | 3744.6231 | 3807.9980 | 3871.3180 |
| 52.399 | 0.13810 | 3389.3876 | 3453.5721 | 3517.7066 | 3581.7904 | 3645.8225 | 3709.8021 | 3773.7204 | 3837.6004 | 3901.4173 |
| 52.599 | 0.13862 | 3415.6064 | 3480.2917 | 3544.9263 | 3609.5099 | 3674.0417 | 3738.5208 | 3802.9403 | 3867.3174 | 3931.6331 |
| 52.799 | 0.13915 | 3441.9273 | 3507.1143 | 3572.2509 | 3637.3364 | 3702.3698 | 3767.3503 | 3832.2770 | 3897.1491 | 3961.9655 |
| 52.999 | 0.13968 | 3468.3487 | 3534.0399 | 3599.6805 | 3665.2697 | 3730.8067 | 3796.2906 | 3861.7204 | 3927.0954 | 3992.4145 |
| 53.199 | 0.14020 | 3494.9712 | 3561.0695 | 3627.2150 | 3693.3099 | 3759.3524 | 3825.3416 | 3891.2765 | 3957.1563 | 4022.9801 |
| 53.399 | 0.14073 | 3521.4947 | 3588.2000 | 3654.8544 | 3721.4570 | 3788.0069 | 3854.5033 | 3920.9453 | 3987.3319 | 4053.6623 |
| 53.599 | 0.14126 | 3548.2192 | 3615.4346 | 3682.5988 | 3749.7110 | 3816.7703 | 3883.7759 | 3950.7268 | 4017.6222 | 4084.4611 |
| 53.799 | 0.14179 | 3575.0448 | 3642.7721 | 3710.4481 | 3778.0718 | 3845.6425 | 3913.1592 | 3980.6210 | 4048.0271 | 4115.3765 |
| 53.999 | 0.14231 | 3601.9715 | 3670.2127 | 3738.4023 | 3806.5395 | 3874.6234 | 3942.6532 | 4010.6279 | 4078.5467 | 4146.4085 |
| 54.199 | 0.14284 | 3628.9992 | 3697.7562 | 3766.4614 | 3835.1141 | 3903.7133 | 3972.2581 | 4040.7476 | 4109.1809 | 4177.5571 |
| 54.399 | 0.14337 | 3656.1280 | 3725.4027 | 3794.6255 | 3863.7956 | 3932.9119 | 4001.9737 | 4070.9799 | 4139.9298 | 4208.8223 |
| 54.599 | 0.14389 | 3683.3577 | 3753.1522 | 3822.9946 | 3892.5839 | 3962.2194 | 4031.8000 | 4101.3250 | 4170.7933 | 4240.2040 |
| 54.799 | 0.14442 | 3710.6896 | 3781.0047 | 3851.2685 | 3921.4791 | 3991.6356 | 4061.7371 | 4131.7827 | 4201.7714 | 4271.7024 |
| 54.999 | 0.14495 | 3738.1205 | 3808.9632 | 3879.7474 | 3950.4812 | 4021.1607 | 4091.7850 | 4162.3532 | 4232.8642 | 4303.3173 |
| 55.199 | 0.14548 | 3765.6534 | 3837.0187 | 3908.3313 | 3979.5902 | 4050.7946 | 4121.9437 | 4193.0363 | 4264.0717 | 4335.0489 |
| 55.399 | 0.14600 | 3793.2874 | 3865.1802 | 3937.0200 | 4008.8061 | 4080.5374 | 4152.2131 | 4223.8322 | 4295.3938 | 4366.8970 |
| 55.599 | 0.14653 | 3821.0224 | 3893.4447 | 3965.8137 | 4038.1288 | 4110.3889 | 4182.5932 | 4254.7408 | 4326.8306 | 4398.8617 |
| 55.799 | 0.14706 | 3848.8585 | 3921.8121 | 3994.7124 | 4067.5584 | 4140.3493 | 4213.0842 | 4285.7621 | 4358.3820 | 4430.9431 |
| 55.999 | 0.14758 | 3876.7957 | 3950.2826 | 4023.7159 | 4097.0949 | 4170.4185 | 4243.6859 | 4316.8960 | 4390.0481 | 4463.1410 |
| 56.199 | 0.14811 | 3904.9335 | 3978.8560 | 4052.8244 | 4126.7383 | 4200.5965 | 4274.3984 | 4348.1427 | 4421.8288 | 4495.4555 |
| 56.399 | 0.14864 | 3932.9731 | 4007.5324 | 4082.0379 | 4156.4885 | 4230.8834 | 4305.2216 | 4379.5022 | 4453.7242 | 4527.8866 |
| 56.599 | 0.14917 | 3961.2133 | 4036.3119 | 4111.3563 | 4186.3456 | 4261.2790 | 4336.1556 | 4410.9743 | 4485.7342 | 4560.4343 |
| 56.799 | 0.14969 | 3989.5547 | 4065.1943 | 4140.7796 | 4216.3096 | 4291.7835 | 4367.2003 | 4442.5591 | 4517.8588 | 4593.0986 |
| 56.999 | 0.15022 | 4017.9970 | 4094.1797 | 4170.3078 | 4246.3805 | 4322.3948 | 4398.3559 | 4474.2566 | 4550.0982 | 4625.8795 |
| 57.199 | 0.15075 | 4046.5404 | 4123.2681 | 4199.9410 | 4276.5583 | 4353.1190 | 4429.6222 | 4505.0669 | 4582.4521 | 4658.7769 |
| 57.399 | 0.15127 | 4075.1849 | 4152.4595 | 4229.6791 | 4306.8429 | 4383.9499 | 4460.9992 | 4537.9898 | 4614.9207 | 4691.7910 |
| 57.599 | 0.15180 | 4103.9304 | 4181.7538 | 4259.5221 | 4337.2344 | 4414.8897 | 4492.4870 | 4570.0254 | 4647.5040 | 4724.9217 |
| 57.799 | 0.15233 | 4132.7772 | 4211.1512 | 4289.4731 | 4367.7328 | 4445.9383 | 4524.0856 | 4602.1738 | 4680.2019 | 4758.1609 |
| 57.999 | 0.15286 | 4161.7244 | 4240.6516 | 4319.5230 | 4398.3380 | 4477.0957 | 4555.7949 | 4634.4349 | 4713.0145 | 4791.5328 |
| 58.199 | 0.15339 | 4190.7732 | 4270.2549 | 4349.6809 | 4429.0502 | 4508.3519 | 4587.6150 | 4666.8086 | 4745.9417 | 4825.0132 |
| 58.399 | 0.15391 | 4219.9233 | 4299.9613 | 4379.9437 | 4459.8692 | 4539.7369 | 4619.5457 | 4699.2951 | 4778.9836 | 4858.6103 |
| 58.599 | 0.15444 | 4249.1737 | 4329.7706 | 4410.3114 | 4490.7951 | 4571.2228 | 4651.5875 | 4731.8943 | 4812.1401 | 4892.3239 |
| 58.799 | 0.15496 | 4278.5295 | 4359.5829 | 4440.7840 | 4521.8279 | 4602.8135 | 4683.7399 | 4764.6062 | 4845.4113 | 4926.1542 |
| 58.999 | 0.15549 | 4307.9784 | 4389.5983 | 4471.3616 | 4552.9675 | 4634.5150 | 4716.0031 | 4797.4308 | 4878.7971 | 4960.1010 |
| 59.199 | 0.15602 | 4337.5321 | 4419.4166 | 4502.0441 | 4584.2141 | 4666.3254 | 4748.3770 | 4830.3681 | 4912.2976 | 4994.1644 |
| 59.399 | 0.15655 | 4367.1877 | 4450.0378 | 4532.8316 | 4615.5675 | 4698.2445 | 4780.8617 | 4863.4181 | 4945.9127 | 5028.3444 |
| 59.599 | 0.15707 | 4396.9432 | 4480.3621 | 4563.7240 | 4647.0277 | 4730.2725 | 4813.4572 | 4896.5806 | 4979.6425 | 5062.6410 |
| 59.799 | 0.15760 | 4426.9002 | 4510.7894 | 4594.7213 | 4678.5949 | 4762.4093 | 4846.1634 | 4929.8563 | 5013.4869 | 5097.0542 |
| 59.999 | 0.15813 | 4456.7581 | 4541.3197 | 4625.8236 | 4710.2689 | 4794.6549 | 4878.9804 | 4963.2444 | 5047.4460 | 5131.8840 |

| Q1 | Q2 | 60 DEG F | 70 DEG F | 80 DEG F | 90 DEG F | 100 DEG F | 110 DEG F | 120 DEG F | 130 DEG F | 140 DEG F |
|---|---|---|---|---|---|---|---|---|---|---|
| 60.000 | 0.15813 | 4456.7588 | 4541.3201 | 4625.8240 | 4710.2694 | 4794.6553 | 4878.9808 | 4963.2449 | 5047.4464 | 5131.5845 |
| 60.200 | 0.15865 | 4486.8179 | 4571.9534 | 4657.0312 | 4742.0503 | 4827.3098 | 4911.9086 | 4996.7457 | 5081.5202 | 5166.2309 |
| 60.400 | 0.15918 | 4516.9781 | 4602.6897 | 4688.3433 | 4773.9381 | 4859.4735 | 4944.9471 | 5030.3593 | 5115.7083 | 5200.9938 |
| 60.599 | 0.15971 | 4547.2393 | 4633.5289 | 4719.7604 | 4805.9328 | 4892.0451 | 4978.0966 | 5064.0855 | 5150.0116 | 5235.8734 |
| 60.799 | 0.16023 | 4577.6016 | 4664.4711 | 4751.2824 | 4838.0343 | 4924.7260 | 5011.3566 | 5097.9245 | 5184.4292 | 5270.8696 |
| 60.999 | 0.16076 | 4608.0649 | 4695.5166 | 4782.9093 | 4870.2429 | 4957.5158 | 5044.7272 | 5131.8762 | 5218.9616 | 5305.9823 |
| 61.199 | 0.16129 | 4638.6293 | 4726.6646 | 4814.6412 | 4902.5581 | 4990.4143 | 5078.2088 | 5165.9406 | 5253.5286 | 5341.2117 |
| 61.399 | 0.16182 | 4669.2967 | 4757.9158 | 4846.4780 | 4934.9803 | 5023.4217 | 5111.8311 | 5200.1177 | 5288.3702 | 5376.5576 |
| 61.599 | 0.16234 | 4700.0612 | 4789.2700 | 4878.4197 | 4967.5093 | 5056.5378 | 5145.5042 | 5234.4074 | 5323.2465 | 5412.0202 |
| 61.799 | 0.16287 | 4730.9287 | 4820.7272 | 4910.4666 | 5000.1453 | 5089.7628 | 5179.3181 | 5268.8099 | 5358.2374 | 5447.5993 |
| 61.999 | 0.16340 | 4761.8973 | 4852.2876 | 4942.6180 | 5032.8881 | 5123.0967 | 5213.2427 | 5303.3252 | 5393.3630 | 5483.2951 |
| 62.199 | 0.16392 | 4792.9669 | 4883.9506 | 4974.8745 | 5065.7378 | 5156.5393 | 5247.2781 | 5337.9531 | 5428.5632 | 5519.1076 |
| 62.399 | 0.16445 | 4824.1376 | 4915.7168 | 5007.2360 | 5098.6944 | 5190.0908 | 5281.4243 | 5372.6937 | 5463.8981 | 5555.0363 |
| 62.599 | 0.16498 | 4855.4093 | 4947.5859 | 5039.7024 | 5131.7578 | 5223.7511 | 5315.6812 | 5407.5471 | 5499.3476 | 5591.0818 |
| 62.799 | 0.16551 | 4886.7821 | 4979.5581 | 5072.2738 | 5164.9281 | 5257.5202 | 5350.0489 | 5442.5131 | 5534.9118 | 5627.2439 |
| 62.999 | 0.16603 | 4918.2559 | 5011.6332 | 5104.9500 | 5198.2053 | 5291.3981 | 5384.5273 | 5477.5918 | 5570.5906 | 5663.5226 |
| 63.199 | 0.16656 | 4949.8308 | 5043.8113 | 5137.7312 | 5231.5896 | 5325.3849 | 5419.1165 | 5512.7833 | 5606.3861 | 5699.9179 |
| 63.399 | 0.16709 | 4981.5067 | 5076.0925 | 5170.6174 | 5265.0804 | 5359.4805 | 5453.8165 | 5548.0874 | 5642.2922 | 5736.42[illegible] |
| 63.599 | 0.16761 | 5013.2836 | 5108.4766 | 5203.6085 | 5298.6782 | 5393.6348 | 5488.6272 | 5583.5343 | 5678.3150 | 5773.0[illegible] |
| 63.799 | 0.16814 | 5045.1616 | 5140.9637 | 5236.7049 | 5332.3830 | 5427.9981 | 5523.5488 | 5619.0339 | 5714.4525 | 5809.8033 |
| 63.999 | 0.16867 | 5077.1407 | 5173.5538 | 5269.9054 | 5366.1946 | 5462.4201 | 5558.5810 | 5654.6762 | 5750.7046 | 5846.6650 |
| 64.199 | 0.16920 | 5109.2208 | 5206.2469 | 5303.2111 | 5400.1130 | 5496.9510 | 5593.7240 | 5690.4312 | 5787.0713 | 5883.6433 |
| 64.399 | 0.16972 | 5141.4019 | 5239.0430 | 5336.6221 | 5434.1384 | 5531.5906 | 5628.9779 | 5726.2909 | 5823.5527 | 5920.7381 |
| 64.599 | 0.17025 | 5173.6841 | 5272.9421 | 5370.1379 | 5468.2706 | 5566.3381 | 5664.3426 | 5762.2793 | 5860.1487 | 5957.9496 |
| 64.799 | 0.17078 | 5206.0674 | 5306.9441 | 5403.7586 | 5502.5097 | 5601.1986 | 5699.8177 | 5798.3724 | 5896.8594 | 5995.2776 |
| 64.999 | 0.17130 | 5238.5517 | 5338.0492 | 5437.4842 | 5536.8557 | 5636.1726 | 5735.4038 | 5834.5782 | 5933.6848 | 6032.7223 |
| 65.199 | 0.17183 | 5271.1370 | 5371.2572 | 5471.3148 | 5571.3086 | 5671.2376 | 5771.1007 | 5870.8968 | 5970.6248 | 6070.2835 |
| 65.399 | 0.17236 | 5303.8234 | 5404.5683 | 5505.2503 | 5605.8683 | 5706.4213 | 5806.9083 | 5907.3280 | 6007.6794 | 6107.9613 |
| 65.599 | 0.17289 | 5336.6108 | 5437.9823 | 5539.2907 | 5640.5349 | 5741.7140 | 5842.8267 | 5943.8720 | 6044.8487 | 6145.7557 |
| 65.799 | 0.17341 | 5369.4993 | 5471.4993 | 5573.4360 | 5675.3084 | 5777.1156 | 5878.8558 | 5980.5286 | 6082.1326 | 6183.6667 |
| 65.999 | 0.17394 | 5402.4888 | 5505.1193 | 5607.6863 | 5710.1888 | 5812.6256 | 5914.9957 | 6017.2980 | 6119.5312 | 6221.6943 |
| 66.199 | 0.17447 | 5435.5794 | 5538.8423 | 5642.0416 | 5745.1761 | 5848.2447 | 5951.2464 | 6054.1800 | 6157.0445 | 6259.8385 |
| 66.399 | 0.17499 | 5468.7711 | 5572.6683 | 5676.5017 | 5780.2702 | 5883.9726 | 5987.6078 | 6091.1748 | 6194.6724 | 6298.0993 |
| 66.599 | 0.17552 | 5502.0638 | 5606.5973 | 5711.0668 | 5815.4712 | 5919.8093 | 6024.0800 | 6128.2823 | 6232.4149 | 6336.4767 |
| 66.799 | 0.17605 | 5535.4575 | 5640.6293 | 5745.7369 | 5850.7791 | 5955.7548 | 6060.6630 | 6165.5025 | 6270.2721 | 6374.9707 |
| 66.999 | 0.17658 | 5568.9522 | 5674.7643 | 5780.5118 | 5886.1938 | 5991.8092 | 6097.3567 | 6202.8354 | 6308.2440 | 6413.5813 |
| 67.199 | 0.17710 | 5602.5481 | 5709.0022 | 5815.3917 | 5921.7155 | 6027.9723 | 6134.1612 | 6240.2810 | 6346.3306 | 6452.3084 |
| 67.399 | 0.17763 | 5636.2449 | 5743.3432 | 5850.3766 | 5957.3440 | 6064.2443 | 6171.0765 | 6277.8393 | 6384.5316 | 6491.1522 |
| 67.599 | 0.17816 | 5670.0429 | 5777.7871 | 5885.4563 | 5993.0794 | 6100.6251 | 6208.1025 | 6315.5103 | 6422.8474 | 6530.1126 |
| 67.799 | 0.17868 | 5703.9419 | 5812.3341 | 5920.6610 | 6028.9217 | 6137.1148 | 6245.2393 | 6353.2940 | 6461.2778 | 6569.1895 |
| 67.999 | 0.17921 | 5737.9419 | 5846.9840 | 5955.9607 | 6064.8708 | 6173.7133 | 6282.4869 | 6391.1905 | 6499.8229 | 6608.3831 |
| 68.199 | 0.17974 | 5772.0429 | 5881.7369 | 5991.3653 | 6100.9268 | 6210.4205 | 6319.8452 | 6429.1996 | 6538.4827 | 6647.6932 |
| 68.399 | 0.18026 | 5806.2450 | 5916.5928 | 6026.8748 | 6137.0898 | 6247.2366 | 6357.3142 | 6467.3215 | 6577.2571 | 6687.1199 |
| 68.599 | 0.18079 | 5840.5482 | 5951.5517 | 6062.4892 | 6173.3595 | 6284.1615 | 6394.8941 | 6505.5560 | 6616.1461 | 6726.6633 |
| 68.799 | 0.18132 | 5874.9524 | 5986.6136 | 6098.2086 | 6209.7362 | 6321.1953 | 6432.5847 | 6543.9033 | 6655.1498 | 6766.3232 |
| 68.999 | 0.18185 | 5909.4576 | 6021.7785 | 6134.0329 | 6246.2197 | 6358.3378 | 6470.3861 | 6582.3633 | 6694.2682 | 6806.0997 |
| 69.199 | 0.18237 | 5944.0639 | 6057.0464 | 6169.9622 | 6282.8102 | 6395.5892 | 6508.2982 | 6620.9359 | 6733.5012 | 6845.9928 |
| 69.399 | 0.18290 | 5978.7713 | 6092.4172 | 6205.9963 | 6319.5076 | 6432.9494 | 6546.3211 | 6659.6213 | 6772.8489 | 6886.0025 |
| 69.599 | 0.18343 | 6013.5797 | 6127.8911 | 6242.1355 | 6356.3116 | 6470.4184 | 6584.4548 | 6698.4194 | 6812.3111 | 6926.1288 |
| 69.799 | 0.18395 | 6048.4891 | 6163.4680 | 6278.3795 | 6393.2227 | 6507.9963 | 6622.6992 | 6737.3302 | 6851.8881 | 6966.3717 |
| 69.999 | 0.18448 | 6083.4996 | 6199.1478 | 6314.7285 | 6430.2406 | 6545.6830 | 6661.0544 | 6776.3537 | 6891.5797 | 7006.7312 |
| 70.199 | 0.18501 | 6118.6112 | 6234.9306 | 6351.1824 | 6467.3654 | 6583.4785 | 6699.5204 | 6815.4899 | 6931.3860 | 7047.2072 |
| 70.399 | 0.18554 | 6153.8238 | 6270.8164 | 6387.7413 | 6504.5971 | 6621.3828 | 6738.0971 | 6854.7389 | 6971.3069 | 7087.7999 |
| 70.599 | 0.18606 | 6189.1374 | 6306.8053 | 6424.4051 | 6541.9357 | 6659.3959 | 6776.7846 | 6894.1005 | 7011.3424 | 7128.5092 |
| 70.799 | 0.18659 | 6224.5521 | 6342.8971 | 6461.1738 | 6579.3811 | 6697.5178 | 6815.5828 | 6933.5748 | 7051.4927 | 7169.3350 |
| 70.999 | 0.18712 | 6260.0678 | 6379.0919 | 6498.0474 | 6616.9334 | 6735.7486 | 6854.4918 | 6973.1619 | 7091.7575 | 7210.2775 |
| 71.199 | 0.18764 | 6295.6846 | 6415.3897 | 6535.0260 | 6654.5926 | 6774.0882 | 6893.5116 | 7012.8616 | 7132.1370 | 7251.3369 |
| 71.399 | 0.18817 | 6331.4025 | 6451.7904 | 6572.1096 | 6692.3587 | 6812.5366 | 6932.6422 | 7052.6741 | 7172.6312 | 7292.5122 |
| 71.599 | 0.18870 | 6367.2213 | 6488.2942 | 6609.2980 | 6730.2316 | 6851.0939 | 6971.8835 | 7092.5992 | 7213.2408 | 7333.8044 |
| 71.799 | 0.18923 | 6403.1413 | 6524.9010 | 6646.5914 | 6768.2115 | 6889.7599 | 7011.2356 | 7132.6371 | 7253.9635 | 7375.2132 |
| 71.999 | 0.18975 | 6439.1622 | 6561.6107 | 6683.9898 | 6806.2982 | 6928.5348 | 7050.6984 | 7172.7877 | 7294.8016 | 7416.7387 |
| 72.199 | 0.19028 | 6475.2843 | 6598.4235 | 6721.4930 | 6844.4918 | 6967.4185 | 7090.2720 | 7213.0510 | 7335.7543 | 7458.3807 |
| 72.399 | 0.19081 | 6511.5073 | 6635.3392 | 6759.1012 | 6882.7922 | 7006.4110 | 7129.9563 | 7253.4270 | 7376.8217 | 7500.1393 |
| 72.599 | 0.19133 | 6547.8315 | 6672.3579 | 6796.8144 | 6921.1996 | 7045.5124 | 7169.7515 | 7293.9157 | 7418.0038 | 7542.0145 |
| 72.799 | 0.19186 | 6584.2566 | 6709.4797 | 6834.6324 | 6959.7138 | 7084.7225 | 7209.6574 | 7334.5171 | 7459.3005 | 7584.0063 |
| 72.999 | 0.19239 | 6620.7829 | 6746.7044 | 6872.5555 | 6998.3349 | 7124.0415 | 7249.6740 | 7375.2313 | 7500.7119 | 7626.1147 |
| 73.199 | 0.19292 | 6657.4101 | 6784.0321 | 6910.5834 | 7037.0629 | 7163.4693 | 7289.8015 | 7416.0581 | 7542.2379 | 7668.3397 |
| 73.399 | 0.19344 | 6694.1384 | 6821.4628 | 6948.7163 | 7075.8977 | 7203.0059 | 7330.0396 | 7456.9976 | 7583.8786 | 7710.6813 |
| 73.599 | 0.19397 | 6730.9678 | 6858.9965 | 6986.9541 | 7114.8395 | 7242.6514 | 7370.3886 | 7498.0499 | 7625.6339 | 7753.1396 |
| 73.799 | 0.19450 | 6767.8882 | 6896.6331 | 7025.2968 | 7153.8881 | 7282.4056 | 7410.8483 | 7539.2148 | 7667.5039 | 7795.7142 |
| 73.999 | 0.19502 | 6804.9297 | 6934.3728 | 7063.7445 | 7193.0435 | 7322.2687 | 7451.4188 | 7580.4925 | 7709.4885 | 7838.4056 |
| 74.199 | 0.19555 | 6842.0622 | 6972.2155 | 7102.2971 | 7232.3059 | 7362.2406 | 7492.1001 | 7621.8829 | 7751.5878 | 7881.2135 |
| 74.399 | 0.19608 | 6879.2957 | 7010.1611 | 7140.9547 | 7271.6751 | 7402.3214 | 7532.8920 | 7663.3859 | 7793.8017 | 7924.1381 |
| 74.599 | 0.19661 | 6916.6303 | 7048.2098 | 7179.7171 | 7311.1513 | 7442.5109 | 7573.7948 | 7705.0017 | 7836.1303 | 7967.1792 |
| 74.799 | 0.19713 | 6954.0660 | 7086.3614 | 7218.5846 | 7350.7343 | 7482.8093 | 7614.8084 | 7746.7302 | 7878.5735 | 8010.3370 |
| 74.999 | 0.19766 | 6991.6027 | 7124.6160 | 7257.5569 | 7390.4241 | 7523.2165 | 7655.9327 | 7788.5714 | 7921.1314 | 8053.6113 |
| 75.199 | 0.19819 | 7029.2404 | 7162.9737 | 7296.6342 | 7430.2209 | 7563.7325 | 7697.1677 | 7830.5253 | 7963.8039 | 8097.0022 |
| 75.399 | 0.19871 | 7066.9792 | 7201.4342 | 7335.8164 | 7470.1246 | 7604.3573 | 7738.5136 | 7872.5919 | 8006.5911 | 8140.5098 |
| 75.599 | 0.19924 | 7104.8191 | 7239.9979 | 7375.1036 | 7510.1350 | 7645.0910 | 7779.9702 | 7914.7712 | 8049.4929 | 8184.1338 |
| 75.799 | 0.19977 | 7142.7600 | 7278.6644 | 7414.4957 | 7550.2524 | 7685.9335 | 7821.5375 | 7957.0632 | 8092.5094 | 8227.8746 |
| 75.999 | 0.20029 | 7180.8019 | 7317.4340 | 7453.9927 | 7590.4767 | 7726.8848 | 7863.2156 | 7999.4680 | 8135.6405 | 8271.7319 |
| 76.199 | 0.20082 | 7218.9449 | 7356.3066 | 7493.5947 | 7630.8079 | 7767.9449 | 7905.0045 | 8041.9854 | 8178.8863 | 8315.7058 |
| 76.399 | 0.20135 | 7257.1890 | 7395.2822 | 7533.3016 | 7671.2459 | 7809.1138 | 7946.9042 | 8084.6156 | 8222.2467 | 8359.7953 |
| 76.599 | 0.20188 | 7295.5340 | 7434.3607 | 7573.1134 | 7711.7908 | 7850.3916 | 7988.9146 | 8127.3584 | 8265.7218 | 8404.0033 |
| 76.799 | 0.20240 | 7333.9802 | 7473.5423 | 7613.0302 | 7752.4425 | 7891.7782 | 8031.0318 | 8170.2140 | 8309.3115 | 8448.3270 |
| 76.999 | 0.20293 | 7372.5274 | 7512.8268 | 7653.0519 | 7793.2012 | 7933.2736 | 8073.2677 | 8213.1823 | 8353.0159 | 8492.7673 |
| 77.199 | 0.20346 | 7411.1756 | 7552.2146 | 7693.1785 | 7834.0667 | 7974.8778 | 8115.6104 | 8256.2632 | 8396.0350 | 8537.3241 |
| 77.399 | 0.20399 | 7449.9249 | 7591.7049 | 7733.4101 | 7875.0391 | 8016.5909 | 8158.0639 | 8299.4569 | 8440.7686 | 8581.9976 |
| 77.599 | 0.20451 | 7488.7752 | 7631.2984 | 7773.7466 | 7916.1184 | 8058.4127 | 8200.6282 | 8342.7633 | 8484.8170 | 8626.7877 |
| 77.799 | 0.20504 | 7527.7266 | 7670.9949 | 7814.1880 | 7957.3046 | 8100.3434 | 8243.3032 | 8386.1824 | 8528.9600 | 8671.6943 |
| 77.999 | 0.20557 | 7566.7790 | 7710.7944 | 7854.7344 | 7998.5976 | 8142.3929 | 8286.0889 | 8429.7143 | 8573.2576 | 8716.7176 |
| 78.199 | 0.20609 | 7605.9325 | 7750.6969 | 7895.3857 | 8039.9976 | 8184.5313 | 8328.9855 | 8473.3588 | 8617.6499 | 8761.8574 |
| 78.399 | 0.20662 | 7645.1870 | 7790.7024 | 7936.1419 | 8081.5044 | 8226.7784 | 8371.9928 | 8517.1160 | 8662.1568 | 8807.1138 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 100.599 | 0.26513 | 12630.5549 | 12871.5060 | 13112.3591 | 13353.1127 | 13593.7650 | 13834.3143 | 14074.7589 | 14315.0970 | 14555.3267 |
| 100.799 | 0.26566 | 12681.1269 | 12923.0455 | 13164.4681 | 13405.5998 | 13648.2101 | 13889.7272 | 14131.1394 | 14372.4448 | 14613.6447 |
| 100.999 | 0.26618 | 12731.7999 | 12974.6901 | 13217.4820 | 13460.1739 | 13702.7644 | 13945.2539 | 14187.6326 | 14429.9073 | 14672.0733 |
| 101.199 | 0.26671 | 12782.5739 | 13026.4365 | 13270.2037 | 13513.8647 | 13757.4268 | 14000.8854 | 14244.2354 | 14487.4844 | 14730.6214 |
| 101.399 | 0.26724 | 12833.4459 | 13078.2861 | 13323.0245 | 13567.6625 | 13812.1985 | 14056.6306 | 14300.9571 | 14545.1764 | 14789.2862 |
| 101.599 | 0.26776 | 12884.4251 | 13130.2386 | 13375.9532 | 13621.5672 | 13867.0799 | 14112.4865 | 14357.7894 | 14602.9826 | 14848.0675 |
| 101.799 | 0.26829 | 12935.5023 | 13182.2961 | 13428.9868 | 13675.5787 | 13922.0681 | 14168.4533 | 14414.7324 | 14660.9038 | 14906.9655 |
| 101.999 | 0.26882 | 12986.6834 | 13234.4525 | 13482.1253 | 13729.6971 | 13977.1662 | 14224.5338 | 14471.7892 | 14718.9395 | 14965.9800 |
| 102.199 | 0.26935 | 13037.9597 | 13286.7140 | 13535.3688 | 13783.9224 | 14032.3730 | 14280.7191 | 14528.9586 | 14777.0899 | 15025.[illegible] |
| 102.399 | 0.26987 | 13089.3401 | 13339.0785 | 13588.7172 | 13838.2545 | 14087.6887 | 14337.0181 | 14586.2407 | 14835.3556 | 15084.3568 |
| 102.599 | 0.27040 | 13140.8214 | 13391.5459 | 13642.1706 | 13892.6936 | 14143.1133 | 14393.4279 | 14643.6356 | 14893.7347 | 15143.7232 |
| 102.799 | 0.27093 | 13192.4039 | 13444.1164 | 13695.7288 | 13947.2395 | 14198.6466 | 14449.9486 | 14701.1431 | 14952.2290 | 15203.2041 |
| 102.999 | 0.27145 | 13244.0873 | 13496.7898 | 13749.3921 | 14001.8923 | 14254.2888 | 14506.5797 | 14758.7634 | 15010.8380 | 15262.8016 |
| 103.199 | 0.27198 | 13295.8714 | 13549.5663 | 13803.1602 | 14056.6520 | 14310.0397 | 14563.3218 | 14816.4964 | 15069.5617 | 15322.5157 |
| 103.399 | 0.27251 | 13347.7574 | 13602.4457 | 13857.0333 | 14111.5189 | 14365.8996 | 14620.1747 | 14874.3421 | 15128.4000 | 15382.3464 |
| 103.599 | 0.27304 | 13399.7439 | 13655.4281 | 13911.0113 | 14166.4919 | 14421.8682 | 14677.1383 | 14932.3005 | 15187.3524 | 15442.2937 |
| 103.799 | 0.27356 | 13451.8316 | 13708.5135 | 13965.0943 | 14221.5723 | 14477.9456 | 14734.2127 | 14990.3716 | 15246.4205 | 15502.3576 |
| 103.999 | 0.27409 | 13504.0203 | 13761.7019 | 14019.7822 | 14276.7594 | 14534.1319 | 14791.3978 | 15048.5554 | 15305.6028 | 15562.5381 |
| 104.199 | 0.27462 | 13556.3101 | 13814.9933 | 14073.5750 | 14332.0535 | 14590.4270 | 14848.6937 | 15106.8519 | 15364.8997 | 15622.8351 |
| 104.399 | 0.27514 | 13608.7009 | 13868.3877 | 14127.9727 | 14387.4544 | 14646.8309 | 14906.1004 | 15165.2611 | 15424.3112 | 15683.2488 |
| 104.599 | 0.27567 | 13661.1927 | 13921.8850 | 14182.4754 | 14442.9623 | 14703.3436 | 14963.6179 | 15223.7831 | 15483.8375 | 15743.7791 |
| 104.799 | 0.27620 | 13713.7856 | 13975.4854 | 14237.0831 | 14498.5769 | 14759.9652 | 15021.2461 | 15282.4177 | 15543.4783 | 15804.4259 |
| 104.999 | 0.27673 | 13766.4796 | 14029.1888 | 14291.7956 | 14554.2985 | 14816.6956 | 15078.9850 | 15341.1650 | 15603.2338 | 15865.1894 |
| 105.199 | 0.27725 | 13819.2746 | 14082.9951 | 14346.6131 | 14610.1259 | 14873.5348 | 15136.8348 | 15400.0251 | 15663.1040 | 15926.0694 |
| 105.399 | 0.27778 | 13872.1706 | 14136.9045 | 14401.5356 | 14666.0623 | 14930.4828 | 15194.7953 | 15458.9979 | 15723.0888 | 15987.0661 |
| 105.599 | 0.27831 | 13925.1677 | 14190.9160 | 14456.5630 | 14722.1045 | 14987.5396 | 15252.8665 | 15518.0833 | 15783.1885 | 16048.1793 |
| 105.799 | 0.27883 | 13978.2658 | 14245.0321 | 14511.6953 | 14778.2536 | 15044.7053 | 15311.0486 | 15577.2845 | 15843.4024 | 16109.4092 |
| 105.999 | 0.27936 | 14031.4650 | 14299.2504 | 14566.9325 | 14834.5096 | 15101.9798 | 15369.3414 | 15636.5924 | 15903.7311 | 16170.7556 |
| 106.199 | 0.27989 | 14084.7652 | 14353.5717 | 14622.2747 | 14890.8724 | 15159.3631 | 15427.7449 | 15696.0160 | 15964.1746 | 16232.2186 |
| 106.399 | 0.28041 | 14138.1665 | 14407.9960 | 14677.7218 | 14947.3421 | 15216.8552 | 15486.2592 | 15755.5523 | 16024.7326 | 16293.7982 |
| 106.599 | 0.28094 | 14191.6689 | 14462.5233 | 14733.2738 | 15003.9187 | 15274.4561 | 15544.8843 | 15815.2013 | 16085.4053 | 16355.4944 |
| 106.799 | 0.28147 | 14245.2722 | 14517.1536 | 14788.9308 | 15060.6022 | 15332.1659 | 15603.6202 | 15874.9630 | 16146.1927 | 16417.3072 |
| 106.999 | 0.28200 | 14298.9767 | 14571.8868 | 14844.6927 | 15117.3925 | 15389.9845 | 15662.4558 | 15934.8375 | 16207.0947 | 16479.2366 |
| 107.199 | 0.28252 | 14352.7821 | 14626.7231 | 14900.5596 | 15174.2898 | 15447.9119 | 15721.4242 | 15994.8246 | 16268.1114 | 16541.2826 |
| 107.399 | 0.28305 | 14406.6887 | 14681.6623 | 14956.5314 | 15231.2939 | 15505.9481 | 15780.4923 | 16054.9244 | 16329.2427 | 16603.4452 |
| 107.599 | 0.28358 | 14460.6963 | 14736.7046 | 15012.6081 | 15288.4049 | 15564.0932 | 15839.6712 | 16115.1370 | 16390.4887 | 16665.7244 |
| 107.799 | 0.28410 | 14514.8049 | 14791.8498 | 15068.7897 | 15345.6227 | 15622.3471 | 15898.9609 | 16175.4622 | 16451.8497 | 16728.1201 |
| 107.999 | 0.28463 | 14569.0145 | 14847.0981 | 15125.0763 | 15402.9475 | 15680.7098 | 15958.3613 | 16235.9002 | 16513.3246 | 16790.6324 |
| 108.199 | 0.28516 | 14623.3252 | 14902.4493 | 15181.4678 | 15460.3791 | 15739.1813 | 16017.8725 | 16296.4509 | 16574.9146 | 16853.2614 |
| 108.399 | 0.28569 | 14677.7370 | 14957.9035 | 15237.9643 | 15517.9175 | 15797.7616 | 16077.4945 | 16357.1143 | 16636.6171 | 16916.0070 |
| 108.599 | 0.28621 | 14732.2498 | 15013.4607 | 15294.5657 | 15575.5630 | 15856.4508 | 16137.2272 | 16417.8903 | 16698.4383 | 16978.8691 |
| 108.799 | 0.28674 | 14786.8637 | 15069.1209 | 15351.2720 | 15633.3152 | 15915.2488 | 16197.0707 | 16478.7791 | 16760.3722 | 17041.8479 |
| 108.999 | 0.28727 | 14841.5786 | 15124.8861 | 15408.0833 | 15691.1744 | 15974.1556 | 16257.0250 | 16539.7806 | 16822.4207 | 17104.9432 |
| 109.199 | 0.28779 | 14896.3946 | 15180.7502 | 15464.9995 | 15749.1404 | 16033.1712 | 16317.0900 | 16600.8948 | 16884.5839 | 17168.1551 |
| 109.399 | 0.28832 | 14951.3116 | 15236.7194 | 15522.0206 | 15807.2133 | 16092.2956 | 16377.2658 | 16662.1218 | 16946.8646 | 17231.4837 |
| 109.599 | 0.28885 | 15006.3296 | 15292.7916 | 15579.1467 | 15865.3931 | 16151.5289 | 16437.5524 | 16723.4614 | 17009.2542 | 17294.9288 |
| 109.799 | 0.28938 | 15061.4487 | 15348.9867 | 15636.3777 | 15923.6797 | 16210.8710 | 16497.9497 | 16784.9137 | 17071.7613 | 17358.4905 |
| 109.999 | 0.28990 | 15116.6689 | 15405.2449 | 15693.7136 | 15982.0732 | 16270.3219 | 16558.4577 | 16846.4788 | 17134.3831 | 17422.1688 |
| 110.199 | 0.29043 | 15171.9901 | 15461.6260 | 15751.1545 | 16040.5736 | 16329.8816 | 16619.0766 | 16908.1565 | 17197.1195 | 17485.9637 |
| 110.399 | 0.29096 | 15227.4124 | 15518.1101 | 15808.7003 | 16099.1809 | 16389.5501 | 16679.8062 | 16969.9470 | 17259.9706 | 17549.8752 |
| 110.599 | 0.29148 | 15282.9357 | 15574.6973 | 15866.3510 | 16157.8951 | 16449.3275 | 16740.6465 | 17031.8501 | 17322.9364 | 17613.9033 |
| 110.799 | 0.29201 | 15338.5600 | 15631.3874 | 15924.1067 | 16216.7161 | 16509.2137 | 16801.5977 | 17093.8660 | 17386.0168 | 17678.0480 |
| 110.999 | 0.29254 | 15394.2854 | 15688.1805 | 15981.9673 | 16275.6440 | 16569.2087 | 16862.6596 | 17155.9946 | 17449.2118 | 17742.3092 |
| 111.199 | 0.29307 | 15450.1119 | 15745.0766 | 16039.9329 | 16334.6788 | 16629.3126 | 16923.8322 | 17218.2359 | 17512.5215 | 17806.6871 |
| 111.399 | 0.29359 | 15506.0393 | 15802.0757 | 16098.0033 | 16393.8205 | 16689.5253 | 16985.1157 | 17280.5899 | 17575.9459 | 17871.1816 |
| 111.599 | 0.29412 | 15562.0679 | 15859.1777 | 16156.1787 | 16453.0690 | 16749.8467 | 17046.5099 | 17343.0565 | 17639.4849 | 17935.7927 |
| 111.799 | 0.29465 | 15618.1974 | 15916.3828 | 16214.4591 | 16512.4245 | 16810.2770 | 17108.0148 | 17405.6360 | 17703.1385 | 18000.5203 |
| 111.999 | 0.29517 | 15674.4281 | 15973.6909 | 16272.8444 | 16571.8868 | 16870.8162 | 17169.6306 | 17468.3281 | 17766.9068 | 18065.3646 |
| 112.199 | 0.29570 | 15730.7598 | 16031.1619 | 16331.3346 | 16631.4560 | 16931.4661 | 17231.3571 | 17531.1329 | 17830.7898 | 18130.3254 |
| 112.399 | 0.29623 | 15787.1925 | 16088.6160 | 16389.9298 | 16691.1320 | 16992.2208 | 17293.1943 | 17594.0504 | 17894.7874 | 18195.4029 |
| 112.599 | 0.29676 | 15843.7263 | 16146.2330 | 16448.6298 | 16750.9150 | 17053.0864 | 17355.1424 | 17657.0807 | 17958.8996 | 18260.5969 |
| 112.799 | 0.29728 | 15900.3611 | 16203.9531 | 16507.4349 | 16810.8048 | 17114.0608 | 17417.2011 | 17720.2236 | 18023.1265 | 18325.9075 |
| 112.999 | 0.29781 | 15957.0970 | 16261.7760 | 16566.3449 | 16870.8015 | 17175.1440 | 17479.3707 | 17783.4793 | 18087.4681 | 18391.3347 |
| 113.199 | 0.29834 | 16013.9339 | 16319.7021 | 16625.3597 | 16930.9050 | 17236.3361 | 17541.6510 | 17846.8477 | 18151.9242 | 18456.8786 |
| 113.399 | 0.29886 | 16070.8719 | 16377.7311 | 16684.4796 | 16991.1155 | 17297.6370 | 17604.0421 | 17910.3288 | 18216.4951 | 18522.5389 |
| 113.599 | 0.29939 | 16127.9109 | 16435.8630 | 16743.7043 | 17051.4328 | 17359.0467 | 17666.5439 | 17973.9225 | 18281.1836 | 18588.3160 |
| 113.799 | 0.29992 | 16185.0510 | 16494.0980 | 16803.0340 | 17111.8570 | 17420.5652 | 17729.1565 | 18037.6290 | 18345.9807 | 18654.2095 |
| 113.999 | 0.30044 | 16242.2921 | 16552.4361 | 16862.4687 | 17172.3881 | 17482.1925 | 17791.8799 | 18101.4482 | 18410.8955 | 18720.2197 |
| 114.199 | 0.30097 | 16299.6343 | 16610.8770 | 16922.0082 | 17233.0261 | 17543.9287 | 17854.7140 | 18165.3801 | 18475.9250 | 18786.3465 |
| 114.399 | 0.30150 | 16357.0775 | 16669.4210 | 16981.6527 | 17293.7709 | 17605.7737 | 17917.6589 | 18229.4247 | 18541.0691 | 18852.5899 |
| 114.599 | 0.30203 | 16414.6218 | 16728.0679 | 17041.4021 | 17354.6226 | 17667.7274 | 17980.7146 | 18293.5821 | 18606.3279 | 18918.9499 |
| 114.799 | 0.30255 | 16472.2671 | 16786.8178 | 17101.2565 | 17415.5813 | 17729.7901 | 18043.8810 | 18357.8521 | 18671.7013 | 18985.4265 |
| 114.999 | 0.30308 | 16530.0135 | 16845.6707 | 17161.2158 | 17476.6467 | 17791.9615 | 18107.1583 | 18422.2348 | 18737.1893 | 19052.0196 |
| 115.199 | 0.30361 | 16587.8609 | 16904.6267 | 17221.2901 | 17537.8191 | 17854.2417 | 18170.5462 | 18486.7303 | 18802.7920 | 19118.7294 |
| 115.399 | 0.30413 | 16645.8093 | 16963.6856 | 17281.4492 | 17599.0983 | 17916.6308 | 18234.0449 | 18551.3384 | 18868.5094 | 19185.5557 |
| 115.599 | 0.30466 | 16703.8588 | 17022.8475 | 17341.7233 | 17660.4844 | 17979.1287 | 18297.6546 | 18616.0593 | 18934.3414 | 19252.4987 |
| 115.799 | 0.30519 | 16762.0093 | 17082.1124 | 17402.1024 | 17721.9774 | 18041.7355 | 18361.3746 | 18680.8928 | 19000.2881 | 19319.5582 |
| 115.999 | 0.30572 | 16820.2610 | 17141.4903 | 17462.5863 | 17783.5773 | 18104.4510 | 18425.2057 | 18745.8391 | 19066.3494 | 19386.7343 |
| 116.199 | 0.30624 | 16878.6136 | 17200.9512 | 17523.1753 | 17845.2840 | 18167.2754 | 18489.1475 | 18810.8991 | 19132.5254 | 19454.0271 |
| 116.399 | 0.30677 | 16937.0673 | 17260.5251 | 17583.8691 | 17907.0977 | 18230.2086 | 18553.2000 | 18876.0698 | 19198.8160 | 19521.4364 |
| 116.599 | 0.30730 | 16995.6221 | 17320.2019 | 17644.6679 | 17969.0181 | 18293.2506 | 18617.3633 | 18941.3542 | 19265.2213 | 19588.9623 |
| 116.799 | 0.30782 | 17054.2779 | 17379.9818 | 17705.5717 | 18031.0455 | 18356.4014 | 18681.6374 | 19006.7513 | 19331.7412 | 19656.6049 |
| 116.999 | 0.30835 | 17113.0347 | 17439.8646 | 17766.5803 | 18093.1798 | 18419.6611 | 18746.0222 | 19072.2611 | 19398.3758 | 19724.3640 |
| 117.199 | 0.30888 | 17171.8926 | 17499.8505 | 17827.6938 | 18155.4209 | 18483.0295 | 18810.5178 | 19137.8836 | 19465.1250 | 19792.2397 |
| 117.399 | 0.30941 | 17230.8516 | 17559.9393 | 17888.9124 | 18217.7689 | 18546.5069 | 18875.1242 | 19203.6189 | 19531.9889 | 19860.2319 |
| 117.599 | 0.30993 | 17289.9115 | 17620.1311 | 17950.2358 | 18280.2238 | 18610.0930 | 18939.8414 | 19269.4668 | 19598.9676 | 19928.3409 |
| 117.799 | 0.31046 | 17349.0726 | 17680.4259 | 18011.6642 | 18342.7856 | 18673.7879 | 19004.6692 | 19335.4275 | 19666.0[illegible] | 19996.5663 |
| 117.999 | 0.31099 | 17408.3347 | 17740.8237 | 18073.0976 | 18405.4542 | 18737.5946 | 19069.6079 | 19401.5008 | 19733.2684 | 20064.9084 |
| 118.199 | 0.31151 | 17467.6978 | 17801.3245 | 18134.8358 | 18468.2297 | 18801.5042 | 19134.6573 | 19467.6869 | 19800.5930 | 20133.3671 |
| 118.399 | 0.31204 | 17527.1620 | 17861.9286 | 18196.5791 | 18531.1121 | 18865.5257 | 19199.8175 | 19533.9856 | 19868.0279 | 20201.9424 |
| 118.599 | 0.31257 | 17586.7272 | 17922.6351 | 18258.4272 | 18594.1014 | 18929.6559 | 19265.0386 | 19600.3971 | 19935.5797 | 20270.6342 |
| 118.799 | 0.31310 | 17646.3935 | 17983.4449 | 18320.3803 | 18657.1976 | 18993.8950 | 19330.4734 | 19666.9213 | 20003.2462 | 20339.4427 |
| 118.999 | 0.31362 | 17706.1608 | 18044.3576 | 18382.4382 | 18720.4006 | 19058.2427 | 19395.9526 | 19733.5582 | 20071.0273 | 20408.3677 |
| 119.199 | 0.31415 | 17766.0293 | 18104.3734 | 18444.0912 | 18783.7136 | 19122.0994 | 19461.5859 | 19800.3078 | 20138.9230 | 20477.4093 |
| 119.399 | 0.31468 | 17825.9986 | 18166.4922 | 18506.8691 | 18847.1273 | 19187.2650 | 19527.2800 | 19867.1701 | 20206.9334 | 20546.5676 |
| 119.599 | 0.31520 | 17886.0691 | 18227.7139 | 18569.2419 | 18910.6510 | 19251.9394 | 19593.1048 | 19934.1451 | 20275.0584 | 20615.8424 |
| 119.799 | 0.31573 | 17946.2406 | 18289.0387 | 18631.7196 | 18974.2816 | 19316.7225 | 19659.0403 | 20001.2328 | 20343.2981 | 20685.2338 |
| 119.999 | 0.31626 | 18006.5132 | 18350.4666 | 18694.3022 | 19038.0190 | 19381.6144 | 19725.0866 | 20068.4332 | 20411.6524 | 20754.7418 |

## TABLE D.IV.

### Compressibility Correction Factor (Y)

V1 = .99

| MM/P | V1 | F V1 |
|---|---|---|
| 0.00125000 | 0.99929935 | 1.00939328 |
| 0.00162500 | 0.99908915 | 1.00918096 |
| 0.00200000 | 0.99887896 | 1.00896865 |
| 0.00237500 | 0.99866876 | 1.00875633 |
| 0.00274999 | 0.99845857 | 1.00854401 |
| 0.00312500 | 0.99824837 | 1.00833169 |
| 0.00349999 | 0.99803818 | 1.00811937 |
| 0.00387499 | 0.99782799 | 1.00790706 |
| 0.00424999 | 0.99761779 | 1.00769474 |
| 0.00462499 | 0.99740760 | 1.00748242 |
| 0.00499999 | 0.99719740 | 1.00727010 |
| 0.00537499 | 0.99698721 | 1.00705779 |
| 0.00574999 | 0.99677701 | 1.00684547 |
| 0.00612499 | 0.99656682 | 1.00663315 |
| 0.00649999 | 0.99635662 | 1.00642083 |
| 0.00687499 | 0.99614643 | 1.00620852 |
| 0.00724999 | 0.99593623 | 1.00599620 |
| 0.00762499 | 0.99572604 | 1.00578388 |
| 0.00799999 | 0.99551585 | 1.00557155 |
| 0.00837499 | 0.99530565 | 1.00535924 |
| 0.00874999 | 0.99509546 | 1.00514693 |
| 0.00912499 | 0.99488526 | 1.00493461 |
| 0.00949999 | 0.99467507 | 1.00472229 |
| 0.00987499 | 0.99446487 | 1.00450997 |
| 0.01024999 | 0.99425468 | 1.00429766 |
| 0.01062499 | 0.99404448 | 1.00408534 |
| 0.01099999 | 0.99383429 | 1.00387302 |
| 0.01137499 | 0.99362410 | 1.00366071 |
| 0.01174999 | 0.99341390 | 1.00344839 |
| 0.01212499 | 0.99320371 | 1.00323607 |
| 0.01249999 | 0.99299351 | 1.00302375 |
| 0.01287499 | 0.99278332 | 1.00281143 |
| 0.01324999 | 0.99257312 | 1.00259911 |
| 0.01362499 | 0.99236293 | 1.00238680 |
| 0.01399999 | 0.99215273 | 1.00217449 |
| 0.01437499 | 0.99194254 | 1.00196216 |
| 0.01474999 | 0.99173234 | 1.00174984 |
| 0.01512499 | 0.99152215 | 1.00153752 |
| 0.01549999 | 0.99131195 | 1.00132521 |
| 0.01587499 | 0.99110176 | 1.00111289 |
| 0.01624999 | 0.99089157 | 1.00090057 |
| 0.01662499 | 0.99068137 | 1.00068825 |
| 0.01699999 | 0.99047118 | 1.00047594 |
| 0.01737499 | 0.99026098 | 1.00026362 |
| 0.01774999 | 0.99005079 | 1.00005130 |
| 0.01812499 | 0.98984059 | 0.99983898 |
| 0.01849999 | 0.98963040 | 0.99962667 |
| 0.01887499 | 0.98942020 | 0.99941435 |
| 0.01924999 | 0.98921001 | 0.99920203 |
| 0.01962499 | 0.98899981 | 0.99898971 |
| 0.01999999 | 0.98878962 | 0.99877739 |
| 0.02037499 | 0.98857943 | 0.99856508 |
| 0.02074999 | 0.98836923 | 0.99835276 |
| 0.02112499 | 0.98815904 | 0.99814044 |
| 0.02149999 | 0.98794884 | 0.99792812 |
| 0.02187499 | 0.98773865 | 0.99771581 |
| 0.02224999 | 0.98752845 | 0.99750349 |
| 0.02262499 | 0.98731826 | 0.99729117 |
| 0.02299999 | 0.98710806 | 0.99707885 |
| 0.02337499 | 0.98689787 | 0.99686654 |
| 0.02374999 | 0.98668767 | 0.99665422 |
| 0.02412499 | 0.98647748 | 0.99644190 |
| 0.02449999 | 0.98626729 | 0.99622958 |
| 0.02487499 | 0.98605709 | 0.99601726 |
| 0.02524999 | 0.98584690 | 0.99580495 |
| 0.02562499 | 0.98563670 | 0.99559263 |
| 0.02599999 | 0.98542651 | 0.99538031 |
| 0.02637499 | 0.98521631 | 0.99516799 |
| 0.02674999 | 0.98500612 | 0.99495568 |
| 0.02712499 | 0.98479592 | 0.99474336 |
| 0.02749999 | 0.98458573 | 0.99453104 |
| 0.02787499 | 0.98437553 | 0.99431872 |
| 0.02824999 | 0.98416534 | 0.99410640 |
| 0.02862499 | 0.98395515 | 0.99389409 |
| 0.02899999 | 0.98374495 | 0.99368177 |
| 0.02937499 | 0.98353476 | 0.99346945 |
| 0.02974999 | 0.98332456 | 0.99325713 |
| 0.03012499 | 0.98311437 | 0.99304482 |
| 0.03049999 | 0.98290417 | 0.99283250 |
| 0.03087499 | 0.98269398 | 0.99262018 |
| 0.03124999 | 0.98248378 | 0.99240786 |
| 0.03162499 | 0.98227359 | 0.99219555 |
| 0.03199999 | 0.98206340 | 0.99198323 |
| 0.03237499 | 0.98185320 | 0.99177091 |
| 0.03274999 | 0.98164301 | 0.99155859 |
| 0.03312499 | 0.98143281 | 0.99134627 |
| 0.03349999 | 0.98122262 | 0.99113396 |
| 0.03387499 | 0.98101242 | 0.99092164 |
| 0.03424999 | 0.98080223 | 0.99070932 |
| 0.03462499 | 0.98059203 | 0.99049700 |
| 0.03499999 | 0.98038184 | 0.99028469 |
| 0.03537499 | 0.98017164 | 0.99007237 |
| 0.03574999 | 0.97996145 | 0.98986005 |
| 0.03612499 | 0.97975125 | 0.98964773 |
| 0.03649999 | 0.97954106 | 0.98943542 |
| 0.03687499 | 0.97933087 | 0.98922310 |
| 0.03724999 | 0.97912067 | 0.98901078 |
| 0.03762499 | 0.97891048 | 0.98879846 |
| 0.03799999 | 0.97870028 | 0.98858614 |
| 0.03837499 | 0.97849009 | 0.98837383 |

# APPENDIX E

## Incinerator Operating Instructions

### Part A: Top Section Preheat

1. Check oil level in front and rear bearing of Hoffman Blower. Fill with Mobil DTE Heavy Medium, if necessary.

2. Close the following valves:

   a) inlet valve to Hoffman Blower
   b) all valves on overfire and underfire air supply line (6)
   c) valves on air lines to gas burners (2 globe valves and 2 butterfly valves)
   d) valves on air line to gas pilot lights (2 gas cocks)
   e) valve from regulator 125# oil free air line (if oil free compressor is necessary)

3. If an air supply in excess of 470 cfm is required sign up for the use of the oil free compressor located in the basement of Building 31. Start compressor as per instructions in Part G.

4. Remove counterweight and close Heat Shield; replace counterweight.

5. Turn on cooling water to:

   a) Top Section
   b) Heat Shield
   c) Gas Probe in Stack

6. Switch on instrument power to Honeywell Electronik 16, allow instrument to warm up for at least 2 hours to obtain greatest recording accuracy. Switch on power to chart drive system when recording is desired. Mode of operation:

   a) Selectoprint
   b) Chart speed = x4

7. Switch on power to air pressure warning system.

8. Start Hoffman Blower. Current should decrease to around 10 amps after 15 seconds.

9. Open pneumatic valve to Hoffman Blower and valve from regulator (if excess capacity is required) slowly. Open valves to the point where potential air delivery is slightly in excess of requirements. To insure that this condition is met the valve settings will have to be checked and adjusted, if necessary, throughout the Start-Up procedure.

10. Open globe valves on air plenum to gas burners.

11. Open globe valves on air supply lines (which will be used during the run) and adjust flow rates to desired levels.

12. Open butterfly valves to both gas burners (about 1/8 open) and valves to both pilots (1/4 - 1/2 open).

13. Open main gas valve and pilot light gas valve.

14. Check to make sure emergency gas shut-off valve is open.

15. Turn on gas to gas lighter probe and ignite. Adjust flame to about 2 inches in length.

16. With lighter in manual ignition port of East burner pilot, turn on gas to pilot. Adjust fuel/air ratio control screw, if necessary, to achieve ignition.

17. After ignition has been achieved wait until pilot flame has stabilized in pilot nozzle throat (Blue flame can be seen through manual ignition port). Adjust pilot flame to 3 - 4 inches in length. Flame should be long enough to provide prompt ignition of the main burners but should not impinge on far side of main burner nozzle. Size of pilot flame can be checked by viewing through hole located 180 degrees from the main burner peep sight. Lock fuel/air ratio control screw.

18. Open main burner gas cock. If ignition is not achieved in 10-15 seconds close gas cock and wait for one minute before attempting ignition again, When ignition is achieved adjust fuel/air ratio control screw until flame is running about 10% lean -- flame bluish and touched with yellow. Lock control screw and replace protective cap; fuel/air ratio will now remain approximately constant over all operating ranges of burner.

19. Allow combustion block of burner to heat up before making any adjustments to the burner air flow rate or igniting North burner and pilot.

20. Wait until temperature of top section is around 400° - 500°C before igniting North burner pilot. Adjust as before.

21. While waiting for top section (see Steps 22, 23, 24) to heat up, proceed with Parts B and C.

22. Slowly heat up top section to operating temperature over a period of 3 - 4 hours. Start by slowly increasing the air flow to East burner. When pressure at burner throat reaches about 0.25 inches $H_2$) and hood temperature is about 600° - 800°C, ignite North burner in manner outlined for East burner. Allow North burner block to heat up before making any substantial changes in air supply flow.

23. Adjust both burners so that the heat outputs from both are equal (i.e., P's at burner throats are equal).

24. Hold top section temperature at desired level for 20 - 30 minutes. Make sure all temperature gradients have stabilized before starting the run by checking all top section refractory and shell temperatures.

Part B: Preparation of Fuel Bed Section

1. Before starting a run, and before the gas burners are fired, the bottom section must be moved out from under neath the top section, in preparation for charging the feedstock. (see Part I, Note 1 on lowering the fuel bed section onto the load cell; Note 2 for raising the fuel bed section off the load cell; and Note 3 for raising and lowering the bottom section.) Generally the bottom section will have been moved out at the end of every run; if not, complete Steps 2 through 9 in Part F.2.

2. Check that load cell control switch is off. Turn the load cell constant voltage supply on. Switch control switch to "350 ohms" and allow power supply to warm up for 15 minutes. Check that the voltage supply is set at 12 + 0.1 volts. NEVER PUT CONTROL SWITCH ON "LOAD CELL" BEFORE CHECKING THE VOLTAGE OUTPUT OF POWER SUPPLY.

3. Plug load cell cable into appropriate connector on West wall panel. Set control switch to "Load Cell" and allow to warm up 1 hour before taking any readings. While the load cell is warming up complete Steps 4 through 16.

# Table E.I

## Instrument Connections

| Lower Switchboard Panel Connection Number | Honeywell/DAS Cold Junction Connection Box Number | Honeywell Electronik 16 Connection Number | Gas Probe Junction Box Number | Instrument or Probe | Location of Instruments and Probes |
|---|---|---|---|---|---|
| 1 | | | | Fuel Bed Thermocouple Number 1 | Thermocouple Number 1 is located 4 inches from the top of the fuel bed (i.e. top of bottom male doughnut) Thermocouples are located in three banks, nine per bank, with each bank separated by 120° from the others. The thermocouples are located on a 3" left hand screw pitch |
| 2 | | | | " 2 | |
| 3 | | | | " 3 | |
| 4 | | | | " 4 | |
| 5 | | | | " 5 | |
| 6 | | | | " 6 | |
| 7 | | | | " 7 | |
| 8 | | | | " 8 | |
| 9 | | | | " 9 | |
| 10 | | | | " 10 | |
| 11 | | | | " 11 | |
| 12 | | | | " 12 | |
| 13 | | | | " 13 | |
| 14 | | | | " 14 | |
| 15 | | | | " 15 | |
| 16 | | | | " 16 | |
| 17 | | | | " 17 | |
| 18 | | | | " 18 | |
| 19 | | | | " 19 | |
| 20 | | | | " 20 | |
| 21 | | | | " 21 | |
| 22 | | | | " 22 | |
| 23 | | | | " 23 | |
| 24 | | | | " 24 | |
| 25 | | | | " 25 | |
| 26 | | | | " 26 | |
| 27 | | | | " 27 | |
| 28 | | | | Bottom Section Heat Loss Probe Number 1, T.C. 1 | Middle of Bottom Section, North |
| 29 | | | | " T.C. 2 | |
| 30 | | | | " T.C. 3 | |
| 31 | | | | Indicater Channel | |
| 32 | | | | Smoke Meter Output | Stack |
| 33 | | | | Load Cell Output | |
| 34 | | | | Load Cell Input | |
| | | | | Top Section Refractory | |
| 35 | 1 | 1 | | T.C. Number 1 | Bottom Row East |
| 36 | 2 | 2 | | " " T.C. Number 2 | Bottom Row West |
| 37 | 3 | 3 | | " " T.C. Number 3 | Second Row North |
| 38 | 4 | 4 | | " " T.C. Number 4 | Second Row South |
| 39 | 5 | 5 | | " " T.C. Number 5 | Third Row East |
| 40 | 6 | 6 | | " " T.C. Number 6 | Third Row West |
| 41 | 7 | 7 | | " " T.C. Number 7 | Top Row South |
| 42 | 8 | 8 | | " " T.C. Number 8 | Top Row North |
| 43 | 9 | 9 | | Stack Gas Temp | |
| | | | | Top Section Surface Shell | |
| 44 | 10 | 10 | | Temp T.C. Number 1 | East |
| 45 | 11 | 11 | | " Temp T.C. Number 2 | South |
| 46 | 12 | 12 | | " Temp T.C. Number 3 | West |
| 47 | 13 | 13 | | Inlet Air Temp | Air Distribution Plenum |
| 48 | 14 | 14 | | Heat Shield Temperature | North, middle of tray |
| 49 | 15 | 15 | | | |
| | 16 | 16 | | Cooling water inlet temp | |
| | 17 | 17 | | Cooling water outlet temp | Heat Shield |
| | 18 | 18 | | Cooling water outlet temp | Top Section |
| | 19 | 19 | | | |
| | 20 | 20 | | | |
| | | 21 | | | |
| | | 22 | | | |
| | | 23 | | | |
| | | 24 | | | |
| 50 | | | 1 | Gas Probe 1, $O_2$ | Stack |
| 51 | | | 2 | " " 1, $CO_2$ | |
| 52 | | | 3 | " " 1, CO | |
| 53 | | | 4 | " " 2, $O_2$ | Fuel Bed |
| 54 | | | 5 | " " 2, $CO_2$ | |
| 55 | | | 6 | " " 2, CO | |
| 56 | | | 7 | " " 3, $O_2$ | Fuel Bed |
| 57 | | | 8 | " " 3, $CO_2$ | |
| 58 | | | 9 | " " 3, CO | |
| | | | 10 | | |
| | | | 11 | | |
| | | | 12 | | |
| | | | 13 | | |
| | | | 14 | | |
| | | | 15 | | |
| | | | 16 | | |
| | | | 17 | | |
| | | | 18 | | |
| 59 | | | | | |
| 60 | | | | | |

4. Complete Part A of the Log Sheet.

5. Install and connect up thermocouples and gas probes that will be used during a run; however, do not push thermocouples and gas probes all the way through to the fuel bed region, until fuel bed is charged. Turn on cooling water to fuel bed probe.

6. Note, on the log sheet, the locations and connection numbers of all thermocouples and gas probes.

7. Connect up all outputs through the switchboard to the D.A.S. Note, on the log sheet, the appropriate connection sequences. (Connections must be made with the indication channel in position one and all of the thermocouples grouped together.) See Table E.I. for instrument connections.

8. Turn on the D.A.S. and synchronize the clock with the clock on the main panel. When taking a punched tape record do not put any blank spaces between sets of readings. Turn on low tape alarm system.

9. Set up appropriate operation mode of D.A.S. (See Part H.)

10. Set up appropriate hydraulic jack and grate assembly for the run.

11. Attach underfire air line to the grate and raise the grate to give desired fuel bed depth.

12. Disconnect the hydraulic leads to the jack and turn off pump.

13. Prepare reference junction for thermocouples by filling Dewar with an ice and water mixture.

14. Drain any moisture from the lead to smoke probe to Smoke Meter. Connect up Smoke Meter and check out operation as per manual. Make sure that the tape drive mechanism is operating correctly and that output to D.A.S. at 100% reflectance is about 80 mv.

15. Take five to ten readings (Printed Tape) of Load Cell voltage output with Fuel Bed Section off Load Cell. Output should be ≈0.036 mv/V.

16. Carefully lower Fuel Bed Section onto the Load Cell (see Note 1).

17. Switch power for indication circuit to "ON."

18. Turn on "Dead weight and 0% for oxygen, since this reading has to be made simultaneously with the dead weight reading.

19. Take five to ten more readings (Punched and Printed Tape) of Load Cell and oxygen meter data.

20. Turn off "Dead weight and 0% oxygen" switch.

21. Raise Fuel Bed Section off Load Cell (see Note 2).

22. Charge feed to Fuel Bed Section inserting thermocouples and gas probes into the fuel bed as it is built up.

23. Note on the log sheet the radial position of all thermocouples and gas probes.

24. Lower Fuel Bed Section onto Load Cell (see Note 1).

25. Take five more readings (Printed Tape only) of Load Cell data.

26. Move Bottom Section back into place under the Top Section -- make sure front wheel is up against stop.

27. Complete the electrical circuit for locating probes. Connections for power are made on the West wall panel.

28. Raise Bottom Section (see Note 3) until locating probe lights are just on. Remove spacers on support jacks and lower Fuel Bed Section onto Load Cell (see Note 1).

29. Take five readings (Printed Tape only) of Load Cell data. Compare these readings with those taken before the Bottom Section was put in place (i.e., Step 25). If the two readings are not identical then there is a drag on the Bottom Section. To reduce the drag:

    a) Raise Bottom Section off Load Cell.
    b) Lower Bottom Section slightly.
    c) Place Bottom Section back on Load Cell and obtain five additional readings.

30. Turn on "Fuel Bed weight and 21% oxygen" switch (amber light). See Part C for 21% oxygen procedure.

31. Take five to ten readings (Punched and Printed Tape) of Load Cell and oxygen meter data.

32. Turn off "Fuel Bed weight and 21% oxygen" switch. Raise Fuel Bed Section off Load Cell (see Note 2). AT THIS POINT IT IS IMPERATIVE THAT THE BOTTOM SECTION IS NOT TOUCHED OR BUMPED.

33. Connect Load Cell output to an oscilloscope so that effect of intermittent vibrations (people walking, vibrating machinery, etc.) can be observed.

34. Connect up the D.A.S. leads from junction box on the Bottom Section to the green panel on back wall of Cell.

35. Turn "Tray Open" switch to "Ready" position.

36. Take about ten readings (Punched and Printed Tape) on the fuel bed thermocouples, Top Section thermocouples, and Load Cell, prior to the start of the run. Record results on Part C of the log sheet.

## Part C: Gas Analysis

C.1. Beckman Carbon Dioxide Analyzer.
The following summarizes the Start-Up and Calibration procedures and is intended for operators familiar with the analyzer. Detailed instructions are given in the Gas Analysis Section.

1. Turn Power Switch to TUNE.

2. Allow instrument to warm up for one hour.

3. Reading should be within one or two of the smallest meter divisions of 45. If so, proceed directly to Step 10; if not, turn oscillator, as explained in Steps 4 - 9.

4. Continue to warm up instrument for an additional half hour with Power Switch in TUNE position.

5. Obtain access to analyzer section by loosening six cover-retaining captive screws, then lift off cover from analyzer section. Chassis slides out on tracks.

6. Loosen lock nut on oscillator tuning screw.

7. With a screwdriver, adjust oscillator tuning screw to obtain peak reading on meter. For accurate determination of maximum reading, approach peak from both directions.

8. Turn oscillator tuning screw counterclockwise until meter reading is between 70% and 75% of maximum value obtained in Step 7. Oscillator is now tuned properly.

9. Turn lock nut on oscillator tuning screw finger-tight, being careful not to change setting of screw.

10. Turn Power Switch to RANGE 1.

11. Set Gain Control at zero on Duodial and Zero Adjust Control at mid-range. (Input signal to a.c. amplifier is now zero. If setting of Bias Adjust is correct, meter reading also should be zero.) If meter reads zero, instrument is ready for calibration. If meter does not read zero, first set Bias Adjust (R29) for zero reading on meter, then calibrate instrument.

12. Turn Power Switch to RANGE 1.

13. If recorder is provided, turn it on. Recorder is more accurate than meter and, if available, should be used for all readings during calibration and operation.

14. Allow instrument to warm up, preferably for one hour. Instrument is operable as soon as turned on, but drifts rapidly at first and requires one hour to equilibrate. If used sooner, readings must be taken immediately after calibration, and instrument must be recalibrated before additional readings are taken later.

15. Set Gain Control at zero on Duodial.

16. Set Zero Adjust Control at mid-range.

17. Note meter reading. If other than zero, set Bias Adjust Control for zero reading.

18. Turn Gain Control to normal operating setting, if known from previous operation. If this setting is not known, use a setting of approximately 500.

19. Pass Zero standard gas through instrument.

20. Set Zero Adjust Control to obtain appropriate reading on meter or recorder. If range of adjustment provided by Zero Adjust is insufficient, first make coarse zero adjustment with appropriate shutter, then fine adjustment with Zero Adjust. Refer to Paragraph

7.4.2 in Beckman Manual. After Zero Adjust is set, lock knob in position.

21. Turn off zero gas.

    Zero point is now set correctly; proceed with following steps to set upscale standardization point(s).

22. Pass upscale standard gas appropriate to Range 1 through intrument.

23. Set Gain Control to obtain appropriate reading on meter or recorder. To determine meter reading corresponding to concentration of component of interest in upscale standard gas, refer to calibration curve inserted at back of manual. After setting Gain Control, lock by pushing lever down.

24. Turn off upscale standard gas.

    Instrument is now calibrated for Range 1. As a check, however, it is recommended that Steps 8 through 13 be repeated once. If instrument is to be calibrated for auxiliary Range 2 (or 3), proceed with following steps. LEAVE GAIN CONTROL AT SETTING ESTABLISHED DURING CALIBRATION OF RANGE 1.

25. Turn Power Switch to RANGE 2 (or RANGE 3).

26. Pass zero standard gas through sample cell; readjust Zero Control if necessary.

27. Pass upscale standard gas appropriate to Range 2 (or3) through sample cell; adjust Adjust Range 2 (or 3) Control for required reading on meter or recorder, as determined from calibration curve at back of manual.

28. As a check, repeat Steps 16 and 17.

29. Connect meter output to Data Acquisition System.

## C.2. Beckman Carbon Monoxide Analyzer

The following summarizes the Start-Up and Calibration procedures and is intended for operators familiar with the analyzer. Detailed instructions are given in the Gas Analysis Section.

1. Place Power Switch at OFF. Front-panel meter should read zero; if not, adjust mechanical zero screw for zero reading.

2. Turn Power Switch to RANGE 1.

3. Allow analyzer to warm up for at least one hour, and preferably for eight hours.

4. Tune oscillator:

    a) Place Power Switch in TUNE position.
    b) Adjust oscillator slug until indicating meter reads maximum.
    c) Adjust slug counterclockwise until indicating meter reads three quarters of maximum.
    d) Place Power Switch at RANGE 1.

5. Turn Gain Control to full counterclockwise position.

6. Indicating meter should now read zero; if not, adjust Bias Control R29 on the adapter board for zero meter reading.

7. Set Gain Control at 500.

8. Flow zero gas through the sample cell.

9. Set Zero Adjust Control at mid-range.

10. Move both reference and sample optical shutters out of the beam.

11. Bring appropriate optical shutter into the associated beam until meter reads zero.

    a) If meter reads below zero, move sample shutter into beam.
    b) If meter reads above zero, move reference shutter into beam.

12. Make final zero adjustment with front-panel Zero Adjust Control.

13. To calibrate for RANGE 1:

    a) Place Power Switch at RANGE 1.
    b) Pass span gas appropriate to Range 1 through sample cell.
    c) From calibration curve, determine correct meter reading for selected span gas.
    d) Adjust front-panel Gain Control for correct meter reading.

Instrument is now calibrated for RANGE 1. If instrument has multiple-range adapter board, and is now to be calibrated for auxiliary range(s), proceed with the following steps.

14. To calibrate for RANGE 2:

    a) Place Power Switch at RANGE 2.
    b) Pass span gas appropriate to RANGE 2 through sample cell.
    c) From calibration curve, determine correct meter reading for selected span gas.
    d) Adjust R135 on adapter board for correct meter reading.

15. To calibrate for RANGE 3:

    a) Place Power Switch at RANGE 3.
    b) Pass span gas appropriate to RANGE 3 through sample cell.
    c) From calibration curve, determine correct meter reading for selected span gas.
    d) Adjust R136 on adapter board for correct meter reading.

16. Set Range Switch for desired operating range: 1, 2, or 3.

17. Connect meter output to Data Acquisition System.

### C.3. Servomex Oxygen Analyzer

### C.3.1. Flow Rate Adjustment

1. The arrangement of inlet and outlet tubes is symmetrical and the sample may therefore be connected to either tube, the other becoming the by-pass outlet. The analyzer outlet should always be allowed to discharge freely to the atmosphere.

2. Close inlet valve and open by-pass valve fully.

3. Connect to sample point and open the inlet valve gradually, observing the reading on the analyzer scale. It may be possible to open the inlet valve fully without producing instability of the reading, which indicates excessive flow rate. If this can be achieved, restrict the by-pass valve gradually until a slight instability of the reading is observed. The analyzer will then respond very quickly and the by-pass valve should be re-opened gradually until the reading becomes stable and is not affected by small adjustments

of the by-pass valve in either direction. This adjustment will automatically give the maximum by-pass flow rate and insure that the analyzer flow rate is within specification.

### C.3.2. Operation

1. Turn power on and allow meter to warm up for at least 1 hour.

2. Adjust amplifier.

   a) Turn operation mode switch to zero.
   b) Adjust amplifier zero screw until meter reads between 0 and 5.

3. Turn operation mode switch to operate.

4. Turn range selection switch to 25.

5. Pass zero calibration gas (i.e., dry nitrogen) through analyzer. Adjust "low" control screw until meter reads 0% oxygen.

6. Pass upper range calibration gas (i.e., dry air) through analyzer. Adjust "high" control screw until meter reads 21% oxygen.

7. Repeat Steps 5 and 6 until no adjustment is necessary when calibration gas is switched from nitrogen to air and vice versa.

8. Connect meter output to Data Acquisition System.

## Part D: Water Analysis

1. Pack 0.25-inch-diameter, 10-inch-long U-shaped glass tubes with stainless steel wool. Packing should not be so tight as to create a sizable pressure drop across the tube. Ends of tubes to be equipped with rubber stoppers.

2. Dry tubes overnight in a vacuum oven maintained at 40°C and 30 inches of vacuum.

3. Weigh each tube assembly (including rubber stoppers) just before the run is initiated and store in a desiccator.

4. Turn on steam to steam-traced moisture sample line. Allow line to drain condensate until it has heated up; then close the drain valve.

5. Set up acetone-Dry Ice bath in Dewar flask.

6. Procedure for taking samples:

   a) Remove rubber stoppers from the ends of sample tube.
   b) Place tube at appropriate position in moisture sample line.
   c) Submerse tube in the acetone-Dry Ice bath; allow temperature of tube and contents to reach that of the bath.
   d) Take zero reading on the wet test meter.
   e) Start the diaphragm pump. Allow the stack gas vapors to be pulled through the condensate collection tube and wet test meter until approximately 0.3 $ft^3$ of gas has passed through system (i.e., 3 revolutions of large dial on wet test meter).
   f) Cut off pump.
   g) Remove collection tube from sample line and Dry Ice bath and immediately insert rubber stoppers.
   h) Dry outside of tube and place back into desiccator for subsequent weighing.
   i) Obtain final reading from wet test meter.
   j) Record time into run, that sample was taken.

7. Weigh sample tubes containing the condensed water vapor.

8. Calculate percent moisture in the stack gas from the weight of water collected and the known volume throughout. See Appendix F.

## Part E: Start and Operation of Run

1. Before starting a run all refractory temperature gradients must have been stabilized for at least 20 - 30 minutes.

2. Check with operator of Gas Train for convenient time to start.

3. Record temperatures of Top Section and cooling water inlet and outlet temperatures before starting on log sheet.

4. Turn on helium tracer to overfire air lines.

5. Start D.A.S. and Smoke Meter 1 minute before run.

6. Fifteen seconds before start shut gas cocks on both burners and pilots.

7. Shut off air supply to burners and pilots.

8. Open Heat Shield carefully. Make sure red indication light on main panel is on when shield is fully opened.

9. Adjust overfire and underfire air flow rates and record on log sheet. Repeat this as necessary during course of run.

10. Turn tray light to OFF when underfire air flow is stabilized.

11. Check operation of Smoke Meter.

12. Determine stack gas moisture content (see Part D) at selected intervals during the run.

13. Collect gas samples, at the end of the gas sample train, at preselected intervals during the run. These samples to be analyzed on the Beckman gas chromatograph at the end of the run.

14. Periodically check the oscilloscope, which is connected to the Load Cell output, for vibration noises.

## Part F: Shut-Down Procedure

F.1. At the completion of the run shut down the equipment as follows:

1. Data Acquisition System

   a) Coupler from REM to INT. DO NOT SWITCH OFF IN THE MIDDLE OF A SCAN.
   b) Run out 2 feet of blank tape.
   c) Switch power to tape punch to OFF.
   d) Change operating mode of Scanner from AUTO to LOCAL.

2. Remove tape from D.A.S., turn off low tape alarm system.

3. Hoffman Blower

4. Exhaust fan

5. 125 psig oil free compressor -- follow instructions in Part G.

6. Smoke Meter

   a) Vacuum pump
   b) Power and tape drive
   c) Remove tape.
   d) Recover meter and recorder with plastic bag.
   e) Open drain plug on sample line.

7. Cooling water to stack gas probe (light must be off). In winter months purge the water out of the coils by opening the "Air Blow Down" valve and waiting until all water has been removed. This will prevent damage to the probe.

8. Cooling water to heat shield -- light must be off.

9. LEAVE COOLING WATER TO TOP SECTION ON FOR AT LEAST 6 HOURS AFTER A RUN. DECREASE FLOW SLIGHTLY -- set valve 3/4 open.

10. Shut off water supply to gas probes; open drain valve.

11. Turn Load Cell switch to OFF.

12. Switch off Load Cell power supply.

13. Turn off main gas valve and main pilot gas valves.

14. Turn off gas to gas lighter probe.

15 Shut down Honeywell Recorder.

   a) Switch off chart power.
   b) Turn off main power switch.
   c) Remove chart section relevant to the run.

16. Raise Bottom Section of Load Cell (see Note 2).

17. Shut down Gas Analysis Train

   a) Switch off vacuum pump.
   b) Turn power switch to OFF on $CO_2$ and CO analyzers.

18. Close all valves on gas cylinders located in cylinder bank outside cell.

19. Turn power off to solenoids by shutting down power to the gas analysis control box.

20. Shut off power to Variacs on gas sample line heating tapes.

F.2. It is advisable to leave the apparatus in this condition until it has cooled down -- approximately 6 hours. After this period:

1. Turn off cooling water to Top Section -- light should be off. In the winter months purge the water out of the coils by opening the "Air Blow Down" valve and waiting until all the water has been removed. This will prevent any possible damage to the coils.

2. Remove all gas probes from Bottom Section.

3. Disconnect Thermocouple line from reference junction jack on West wall panel.

4. Disconnect D.A.S. Cables from junction box to green panel.

5. Disconnect underfire air hose from grate (if used).

6. Disconnect leads for locating probes from Bottom Section to flexible diaphragm.

7. Lower Bottom Section (see Note 1).

8. Slowly pull Bottom Section out from under the Top Section. Lock Bottom Section in place by screwing one of the main leveling jacks down to the point where it touches the floor and provides enough drag to keep the Section stationary. Level Bottom Section by making the appropriate adjustments to leveling jacks.

9. Remove all thermocouples from the Bottom Section.

10. Connect hydraulic leads to jack and lower grate assembly. Disconnect leads.

11. Collect ashes from grate. Weigh ash and note weight on log sheet.

12. Clean Bottom Section thoroughly. DO NOT GET ASH AND DIRT INTO BALL BUSHING.

13. Check the refractory lining in the Top Section and note places requiring repair.

## Part G: Operation of Compressor

(Ingersoll-Rand 125 psig - 450 cfm Oil Free Compressor - located in Gas Turbine Laboratory, Basement, Building 31)

### G.1. Start-Up

1. Check for water in receiver tanks (drain if necessary).
2. Check oil levels (2).
3. Open water supplies for compressor and its aftercooler (2).
4. Set the unloader lever at the push-button station to the vertical position.
5. Start compressor.
6. When compressor has attained constant speed, move the unloader lever to the horizontal position.
7. Regulate flow of cooling water to the compressor so that the discharge from the jacket of the high pressure cylinder to the slight flow funnel is warm to the touch (110° to 120°F maximum). Excessive water flow at the cylinder jackets will cause condensation in the cylinders.
8. The flow of water to the aftercooler should be regulated so that the discharge at the slight flow funnel is cold to the touch.
9. Test Safety Valve by hand.

### G.2. Shutdown

1. Set the unloader lever in the vertical position.
2. Stop compressor.
3. Shut cooling water off from both compressor and aftercooler. Do not permit water to circulate through water jackets and intercooler after the compressor has been shut down -- moisture will form on the cylinder walls and destroy the cylinder bore polish.

4. Fill in compressor operation log -- time recorder located on side of circuit breaker box at rear of compressor.

## Part H: Data Acquisition System Instructions

These abbreviated instructions are for those who are already familiar with the D.A.S. For a complete description see D.A.S. Manual.

### H.1. Normal Operating Mode

1. Sign book stating (i) Name, account number, channel numbers
   (ii) Frequency of scans.
2. Check with present user(s) for (i) Upper limit channel
   (ii) Lower limit channel
   (iii) Frequency of scans
3. Check that cables are plugged into the appropriate channel numbers on the rear of the machine (140-199).
4. Load fresh roll of paper tape; allow two feet of feed holes and use incinerator project's take-up reel.
5. Synchronize clock in cell with clock on D.A.S.

Capital letters refer to buttons which should be pressed.

6. Select lower and upper channel limits.

| | | |
|---|---|---|
| 7. a) | Coupler - Clock | Set START, TIME INTERVAL (behind door of clock) 1 sec, 10 sec, 60 sec, 10 min, 1 hr or multiple<br>REM<br>ON |
| b) | Meter | DC<br>AUTO<br>LOCAL<br>MAN |
| c) | Scanner | AUTO<br>START TIME INTERVAL AND SINGLE SCAN<br>RESET and then START |
| 8. | Typed Copy (if needed) | ON<br>OPER |
| 9. | Punch Tape | ON |

## H.2. Special Operating Modes Used for System Check-Out

Capital letters refer to buttons which should be pressed. Do not follow these procedures until you have checked with all present users.

| | Meter Only | Meter + Typed Copy Only | Meter + Punch Only |
|---|---|---|---|
| Clock | REM<br>OFF | REM<br>OFF | REM<br>ON |
| Meter | DC<br>AUTO<br>LOCAL<br>MAN | DC<br>AUTO<br>LOCAL<br>MAN | DC<br>AUTO<br>LOCAL<br>MAN |
| Typed Copy | OFF | ON | OFF |
| Punched Tape | OFF | OFF | ON<br>Push white button so as to get 2 ft of feed holes. |

Scanner
For monitoring one channel at a time during check-out
Select LOWER and UPPER channel limits
Press LOCAL
Press RESET, START------meter reads channel
Press STEP--------------meter reads next channel up to UPPER LIMIT

## H.3. Punched Tape Removal Instructions

1. Open the clock, and switch the coupler from REM to INT. This stops punching.

2. Press white button to get about two feet of tape.

3. Tear the tape carefully, remove the reel from the spindle (note the threading first), and give it a twist to remove one side in order to lift the tape free. Leave it coiled as it is.

4. Reassemble the reel and replace it on the spindle. Press the white button to obtain about two feet of tape and rethread.

5. Return the coupler to REM. The system is ready to begin operating again.

Part I:

NOTE 1: Lowering the Fuel Bed Section

THIS SHOULD ONLY BE PERFORMED WHEN THE BOTTOM SECTION IS PERFECTLY LEVEL (check spirit level on the base and adjust leveling jacks if necessary). If this is not done damage will occur to the ball bushing, impairing the accuracy of the Load Cell. Once the base is level, slowly lower the Fuel Bed supporting jacks, taking an eighth of a turn on each at a time. This operation is best performed with 2-3 persons, with the jacks being lowered simultaneously. To lower the jacks THE HANDLES ARE TURNED IN A CLOCKWISE DIRECTION. When the weight is off the Fuel Bed supporting jacks, they can be lowered more rapidly, until they are free of the locating rings. ONCE THIS POSITION HAS BEEN REACHED IT IS IMPERATIVE THAT THE FUEL BED SECTION SHOULD NOT BE BUMPED OR TURNED. This will cause severe damage to the ball bushing and support shaft.

NOTE 2: Raising the Fuel Bed Section

Reverse the procedure outlined in Note 1. Raise the jacks until the weight of the Fuel Bed Section is just off the Load Cell (i.e., output of Load Cell is approximately -0.03 mv/V). This only requires about a quarter of a turn once the slack on the jacks is taken up. To raise the jacks THE HANDLES ARE TURNED IN AN ANTICLOCKWISE DIRECTION.

NOTE 3: Raising and Lowering Bottom Section

This operation is performed only when the Fuel Bed Section is raised off the Load Cell and must be done smoothly and slowly. Start by leveling the whole Bottom Section (check spirit level). Once this has been achieved slowly raise all three jacks, one half turn at a time, until the male doughnut of the Bottom Section is just about to mate with the female doughnut of the Top Section. Thereafter raise the jacks only by 1/8 - 1/4 of a turn at a time until the flexible diaphragm meets the flange on the Bottom Section.

To lower the Section, reverse the above procedures; again, the Fuel Bed Section must be raised off the Load Cell.

# APPENDIX F

## Test Incinerator Material Balance

Development of Equations. A material balance calculated at an instant during a run provided information on the instantaneous rate of consumption of the carbon, hydrogen and oxygen content of the fuel; in addition, the rate of fuel weight loss was determined and used as a check against the load cell data.

Figure F.1. shows, schematically, the material inputs to and outputs from the incinerator. It was discovered that it was impossible to seal the test incinerator so that there was no air leakage. Consequently the material balance took the amount of air leakage into the overfire volume into account.

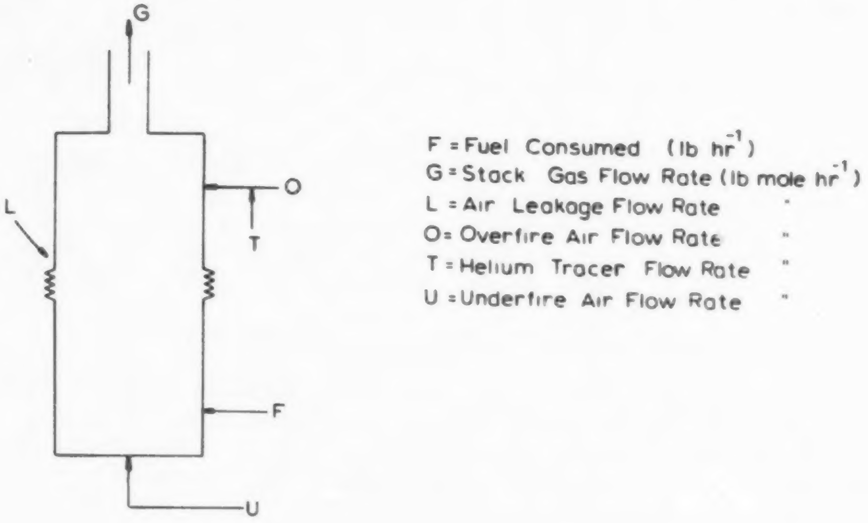
G
L
O
T
F
U
F = Fuel Consumed (lb hr$^{-1}$)
G = Stack Gas Flow Rate (lb mole hr$^{-1}$)
L = Air Leakage Flow Rate "
O = Overfire Air Flow Rate "
T = Helium Tracer Flow Rate "
U = Underfire Air Flow Rate "

Fig. F.1. Schematic of Incinerator Showing Material Inputs and Outputs

At any particular instant during a run four material balances for carbon, hydrogen, oxygen and nitrogen could be written as follows. (In these equations the fuel was assumed to contain only carbon, hydrogen and oxygen, which was a valid assumption for the synthetic refuse used in this study.)

Carbon balance (C)

$$\frac{F.F_C}{12} = G\left(y^G_{CO_2} + y^G_{CO}\right) \tag{F-1}$$

Oxygen balance ($O_2$)

$$\frac{F.F_O}{32} = G\left(y^G_{CO_2} + y^G_{O_2} + y^G_{CO} + \frac{1}{2}y^G_{H_2O}\right) - (U + O + L)\left(y^A_{O_2} + \frac{1}{2}y^A_{H_2O}\right) \tag{F-2}$$

Hydrogen balance ($H_2$)

$$\frac{F.F_H}{2} = G\,y^G_{H_2O} - (U + O + L)\,y^A_{H_2O} \tag{F-3}$$

Nitrogen balance ($N_2$)

$$G y^G_{N_2} = (U + O + L)\,y^A_{N_2} \tag{F-4}$$

In these equations $F_H$, $F_C$, and $F_O$ are, respectively, the weight fraction of hydrogen, carbon and oxygen in the fuel; $y^G_i$ is the mole fraction of component i in the stack gases and $y^A_i$ is the mole fraction of component i in the ambient air.

The above equations were used to solve for the rate of consumption of the oxygen, carbon, and hydrogen content of the fuel ($F.F_O$, $F.F_C$, and $F.F_H$) if either G or L were known. Accurate direct measurement of the stack gas flow rate presented formidable experimental problems and therefore a helium tracer was used. A helium balance gave the addition equation necessary to solve for the fuel unknowns G,L, $F.F_O$, $F.F_H$, and $F.F_C$.

Helium balance (He)

$$T = G\,y^G_{He} \tag{F-5}$$

The air leakage rate was found by dividing equation (F-4) by equation (F-5), giving

$$L = \frac{T}{y^A_{N_2}\left[\dfrac{y^G_{He}}{y^G_{N_2}}\right]} - (U + O) \tag{F-6}$$

The ratio of ($y^G_{He}/y^G_{N_2}$) in equation (F-6) was calculated directly from the chromatographic analysis of the stack gas samples.

All the gas analyses performed on either the gas chromatograph or the nondispersive infrared instruments were on a dry basis, while the gas compositions used in these equations are on a wet basis. The basis on which the gas compositions are given is readily changed using equation (F-7).

$$y^j_i = \bar{y}^j_i \, (1 - y^j_{H_2O}) \qquad \text{(F-7)}$$

where $\bar{y}^j_i$ is the mole fraction of component i in stream j measured on a dry basis.

The nitrogen concentration in the stack gases was not measured directly but calculated from the other measured compositions using the relationship

$$y^G_{N_2} = 1 - y^G_{CO_2} - y^G_{CO} - y^G_{O_2} - y^G_{He} \qquad \text{(F-8)}$$

Under all conditions explored, the carbon monoxide concentration in the stack was undectable using the nondispersive infrared instrument, indicating that $y^G_{CO} < 0.0007$; equation (F-8) then simplifies to

$$y^G_{N_2} = 1 - y^G_{CO_2} - y^G_{O_2} - y^G_{He} \qquad \text{(F-9)}$$

Water Content of Stack Gases. The moisture content of the stack gases was determined using the equipment shown in Figure 48 (b). The moisture content was calculated from the weight of water frozen in the trap and the known volume of gas passed through the trap as follows. It was assumed that the gases from the wet test meter were saturated with water vapor at the temperature and pressure of the wet test meter. If Q$ft^3$ pass through the wet test meter during the collection of a sample, the number of moles of dry gas drawn through the meter is given by

$$Q_m(\text{lb moles}) = \frac{492\ Q\ \Pi}{359(T + 460)} \left\{1 - y^{WTM}_{H_2O}\right\} \qquad \text{(F-10)}$$

where T is the temperature of the water in the wet test meter (°F), $\Pi$ the pressure inside the meter (atm), and $y^{WTM}_{H_2O}$ the mole fraction of the water vapor in the gases leaving the meter. As it was assumed that the gases leaving the meter are saturated with water

$$y_{H_2O}^{WTM} = \frac{VP_{H_2O}\ (T)}{\Pi} \qquad \text{(F-11)}$$

where $VP_{H_2O}$ is the vapor pressure of water at the temperature of the wet test meter.

The amount of gas drawn through the stack gas sampling probes was given by the sum of the amount of dry gas passed through the wet test meter and the amount of water condensed in the U-tube trap. Thus

$$Q_M^{Probe} = \frac{492\ Q\ \Pi}{359(T + 460)} \left\{ 1 - y_{H_2O}^{WTM} \right\} + \frac{G}{454 \times 18} \qquad \text{(F-12)}$$

where G is the weight of water collected (grams). The volume fraction of water in the stack gases is then given by

$$y_{H_2O}^{G} = \frac{G}{(454)\ (18)\ Q_M^{Probe}} \qquad \text{(F-13)}$$

Substituting equation (F-12) into equation (F-13) and assuming that the pressure inside the wet test meter was not significantly different from 1 atm gives

$$y_{H_2O}^{G} = \frac{1}{\left[ 1 + \dfrac{1.12 \times 10^4\ Q \left( 1 - y_{H_2O}^{WTM} \right)}{G(T + 460)} \right]} \qquad \text{(F-14)}$$

The pressure inside the wet test meter never got higher than about 2 inches w.g. and indicated that the approximation used in developing equation (F-14) is valid. Equation (F-14) was used to calculate the concentration of water in the stack gases from the known values of G and Q.

Material Balance Program. The material balance program utilized equations (F-1) through (F-5) with data on T, U, O, $y_{H_2O}^{G}$, $y_{O_2}^{G}$, $y_{CO_2}^{G}$, $y_{CO}^{G}$, $y_{O_2}^{A}$, $y_{N_2}^{A}$, and $y_{H_2O}^{A}$ to calculate G, $F.F_C$, $F.F_H$ and $F.F_O$ at specified times throughout the run. The time increment between the points selected for calculating the material balances was between 100 and 200 sec. The program also calculated the carbon/hydrogen and hydrogen/oxygen ratios in the fuel consumed and the total burning rate ($F.F_C + F.F_O + F.F_H$) at these times and the accumulated weight loss up to any particular elapsed time. The burning rates obtained were integrated over the total specified duration of the run and checked against the known weight of material charged. A similar check was made against the integrated carbon, hydrogen and oxygen losses and the amount of each element charged calculated from the ultimate analysis of the fuel and total weight of fuel charged. The Fortran Program Listing follows.

## Fortran Program for Calculating Test Incinerator Material Balances.

```
C  THIS PROGRAM CALCULATES MATERIAL BALANCES AT DIFFERENT TIMES
C  THROUGHOUT AN EXPERIMENTAL RUN GIVEN THE STACK GAS COMPOSITION AND
C  THE OVERFIRE AND UNDERFIRE AIR FLOW RATES AND COMPOSITIONS
      REAL LEAK(75),INERT
      DIMENSION ATIME(75),F(75),FC(75),FH(75),FO(75),G(75),SUM(75)
     1,TLOSS(75),O(75),H(75),C(75),ALPHA(75),BETA(75),GAMMA(75)
C  READ INPUT PARAMETERS
C                       M = NUMBER OF DATA POINTS USED
C                    IRUN = RUN NUMBER
C                    ZERO = ELAPSED TIME FROM THE START OF RUN THAT FIRST
C  WWOOD, DWOOD, INERT = WEIGHT OF WET WOOD, DRY WOOD AND INERT AT THE
C                          START OF THE RUN (LBS)
C          H2OWW, H2ODW = WEIGHT FRACTIONS OF WATER IN WET AND DRY WOOD
C              CF,HF,OF = WEIGHT FRACTIONS OF CARBON, HYDROGEN AND OXYGEN
C                          IN THE FUEL (DRY BASIS)
C    YO2A, YN2A, YH2OA = VOLUME FRACTIONS OF OXYGEN, NITROGEN AND WATER
C                          VAPOR IN THE OVERFIRE AND UNDERFIRE AIR
      READ(2,102) M,IRUN,ZERO
      READ(2,103) WWOOD,DWOOD,INERT,H2OWW,H2ODW,CF,HF,OF
      READ(2,100) YO2A,YN2A,YH2OA
C  CALCULATE POUNDS OF  WATER IN FUEL
      FH2O=((WWOOD*H2OWW)+(DWOOD*H2ODW))
C  CALCULATE THE TOTAL WEIGHT OF FUEL
      FUEL=WWOOD+DWOOD+INERT
C  CALCULATE WEIGHT FRACTION OF WATER AND INERT IN FUEL
      WFH2O=FH2O/FUEL
      WFIN=INERT/FUEL
C  CALCULATE POUNDS OF DRY COMBUSTIBLE IN FUEL
      COMB=(WWOOD+DWOOD)-FH2O
C  CALCULATE TOTAL POUNDS OF CARBON, HYDROGEN AND OXYGEN IN FUEL
      FCLBS=CF*COMB
      FHLBS=(HF*COMB)+FH2O*2.0/18.0
      FOLBS=(OF*COMB)+FH2O*16.0/18.0
C  CALCULATE CARBON/HYDROGEN, HYDROGEN/OXYGEN AND CARBON/OXYGEN RATIO IN FUEL
      CHA=FCLBS/FHLBS
      HOA=FHLBS/FOLBS
      COA=FCLBS/FOLBS
C  CALCULATE POUNDS OF TOTAL COMBUSTIBLE IN FUEL
      WL=FCLBS+FHLBS+FOLBS
C   WRITE RUN NUMBER,TOTAL FUEL WEIGHT,WEIGHT FRACTION OF WATER AND
C  INERT IN FUEL,MOLE FRACTION OF OXYGEN,NITROGEN AND WATER IN AMBIENT
C  AIR,ELAPSED TIME WHEN FIRST MATERIAL BALANCE IS CALCULATED.
      WRITE(3,206) IRUN
      WRITE(3,210) FUEL,WFH2O,WFIN
      WRITE(3,207) YO2A,YN2A,YH2OA
      WRITE(3,208) ZERO
C  WRITE CAPTION
      WRITE(3,205)
      DO 20 J=1,M
C  READ MATERIAL BALANCE PARAMETERS
C                   TIME = ELAPSED TIME AT WHICH MATERIAL BALANCE IS CALCULATED
C  YGO2, YGCO2, YGH2O = VOLUME FRACTIONS OF OXYGEN, CARBON DIOXIDE AND
C                          IN THE STACK GAS
C               UA, OA = UNDERFIRE AND OVERFIRE AIR FLOW RATES (LB. MOLES/HR)
C                RHEN2 = RATIO OF MOLES HELIUM TO MOLES NITROGEN IN STACK
C                    T = TRACER FLOW RATE (LB. MOLES/HR)
      READ(2,101)TIME,YGO2,YGCO2,YGH2O,UA,OA,RHEN2,T
      ATIME(J)=TIME
      SUM(J) = YGO2+YGCO2
C  CONVERT GAS COMPOSITIONS TO A WET BASIS
      YGCO2 = YGCO2*(1. -YGH2O)
      YGO2 = YGO2*(1. -YGH2O)
C  CALCULATE NITROGEN AND HELIUM CONCENTRATIONS IN STACK GASES
      YGN2=(1.-YGCO2-YGO2-YGH2O)/(1.+RHEN2)
      YGHE = RHEN2*YGN2
C  CALCULATE AIR LEAKAGE RATE
      LEAK(J)=((T*YGN2)/(YN2A*YGHE))-(UA+OA)
      OA=OA+LEAK(J)
C  CALCULATE STACK GAS FLOW RATE
      G(J)=(UA+OA)*(YN2A/YGN2)
C  CALCULATE HYDROGEN, OXYGEN AND CARBON BURNING RATES
      FC(J)=12.0*G(J)*YGCO2
      FO(J)=32.0*G(J)*(YGCO2+YGO2+0.5*YGH2O)-32.0*(UA+OA)*(YO2A+0.5*
     1YH2OA)
      FH(J)=2.0*G(J)*YGH2O-2.0*(UA+OA)*YH2OA
C  CALCULATE TOTAL BURNING RATE
      F(J)=FC(J)+FH(J)+FO(J)
C  CALCULATE C/H, H/O AND C/O RATIO OF FUEL FROM WEIGHTS OF CARBON, HYDROGEN
C  AND OXYGEN BURNT
      ALPHA(J)=FC(J)/FO(J)
      BETA(J)=FH(J)/FO(J)
   20 GAMMA(J)=FC(J)/FH(J)
C  CALCULATE ACCUMULATIVE WEIGHT OF CARBON, HYDROGEN AND OXYGEN BURNT
C  AND TOTAL ACCUMULATIVE WEIGHT OF FUEL BURNT
```

```
      C(1)=ZERO*FC(1)/(2.0*3600.0)
      H(1)=ZERO*FH(1)/(2.0*3600.0)
      O(1)=ZERO*FO(1)/(2.0*3600.0)
      TLOSS(1)=O(1)+H(1)+C(1)
      NJ=M-1
      DO 30 J=1,NJ
      K=J+1
      C(K)=C(J)+(ATIME(K)-ATIME(J))*(FC(K)+FC(J))/(2.0*3600.0)
      CLBS=C(K)
      H(K)=H(J)+(ATIME(K)-ATIME(J))*(FH(K)+FH(J))/(2.0*3600.0)
      HLBS=H(K)
      O(K)=O(J)+(ATIME(K)-ATIME(J))*(FO(K)+FO(J))/(2.0*3600.0)


      OLBS=O(K)
      TLOSS(K)=TLOSS(J)+(ATIME(K)-ATIME(J))*(F(K)+F(J))/(2.0*3600.0)
   30 ALBS=TLOSS(K)
C  CALCULATE C/O, H/O AND C/H RATIO IN FUEL BURNT
      CHC=CLBS/HLBS
      HOC=HLBS/OLBS
      COC=CLBS/OLBS
      DO 40 J=1,M
      ETIME=ATIME(J)+ZERO
C  PRINT RESULTS
   40 WRITE(3,200)     ETIME,F(J),FC(J),FH(J),FO(J),ALPHA(J),BETA(J),
     1GAMMA(J),G(J),LEAK(J),SUM(J),C(J),O(J),H(J),TLOSS(J)
      WRITE(3,202) CLBS,FCLBS
      WRITE(3,203) HLBS,FHLBS
      WRITE(3,204) OLBS,FOLBS
      WRITE(3,201) ALBS,WL
      WRITE(3,211) CHC,CHA
      WRITE(3,212) HOC,HOA
      WRITE(3,213) COC,COA
C  READ NUMBER OF TIMES AVERAGE BURNING RATE IS TO BE CALCULATED
      READ(2,104) NK
      DO 50 JJ=1,NK
C  READ TIMES BETWEEN WHICH AVERAGE BURNING RATE IS TO BE CALCULATED
      READ(2,105) L,N
      NP=N-L
C  CALCULATE AVERAGE BURNING RATE
      CAVE=0.0
      DO 60 J=1,NP
      I=J+L-1
   60 CAVE=CAVE+F(I)
      CAVE=CAVE/NP
      T1=ATIME(L)+ZERO
      T2=ATIME(N)+ZERO
C  PRINT AVERAGE BURNING RATE AND TIMES BETWEEN WHICH IT IS CALCULATED
   50 WRITE(3,209) T1,T2,CAVE
  100 FORMAT(3F10.5)
  101 FORMAT(8F10.5)
  102 FORMAT(2I5, F10.4)
  103 FORMAT(8F10.4)
  104 FORMAT(I5)
  105 FORMAT(2I5)
  200 FORMAT(2X,F6.1,4F7.3,5F8.4,5F7.3)
  201 FORMAT( /, 5X,'INTEGRATED WEIGHT LOSS   = ',F6.3,' LBS',5X,' TOTAL
     1 COMBUSTIBLE CHARGED    = ',F6.3,' LBS',)
  202 FORMAT(//, 5X,'INTEGRATED CARBON LOSS   = ',F6.3,' LBS',5X,' THEOR
     1ETICAL CARBON CHARGED   = ',F6.3,' LBS',)
  203 FORMAT(    5X,'INTEGRATED HYDROGEN LOSS = ',F6.3,' LBS',5X,' THEOR
     1ETICAL HYDROGEN CHARGED = ',F6.3,' LBS',)
  204 FORMAT(    5X,'INTEGRATED OXYGEN LOSS   = ',F6.3,' LBS',5X,' THEOR
     1ETICAL OXYGEN CHARGED   = ',F6.3,' LBS',)
  205 FORMAT(2X,'TIME      F       FC      FH      FO     ALPHA    BETA     GAM
     1MA     G      LEAK     SUM      C       O       H     TLOSS ')
  206 FORMAT('1',30X,'BURNING RATES AND INTEGRATED WEIGHT LOSS FOR RUN '
     1,I4,//,)
  207 FORMAT( 5X,'AMBIENT CONDITIONS    YO2A = ',F6.4,'  YN2A = ',F6.4,'
     1  YH2OA = ',F6.4,)
  208 FORMAT( 5X,'INTEGRATION STARTED ',F5.1,' SECONDS INTO RUN',///,)
  209 FORMAT(/, 5X,'BURNING RATE OVER CONSTANT BURNING PERIOD (FROM',
     1F7.1,' TO',F7.1,' SECONDS) = ',F6.3,' LBS/HR',)
  210 FORMAT( 5X,'TOTAL FUEL CHARGED = ',F6.3,5X,'WT.FRACTION MOISTURE =
     1 ',F6.4,'  WT.FRACTION INERT = ',F6.4,)
  211 FORMAT(//, 5X,'CALCULATED FUEL C/H RATIO = ',F6.3,'         ACTUAL
     1 FUEL C/H RATIO = ',F6.3,)
  212 FORMAT(    5X,'CALCULATED FUEL H/O RATIO = ',F5.3,'         ACTUAL
     1 FUEL H/O RATIO = ',F6.3,)
  213 FORMAT(    5X,'CALCULATED FUEL C/O RATIO = ',F6.3,'         ACTUAL
     1 FUEL C/O RATIO = ',F6.3,)
      CALL EXIT
      END
```

# APPENDIX G

## Data Processing Programs

G.1. Introduction. Three programs were used to process the data from the punched paper tape through to the final plotting stages. The paper tape data were first transferred onto magnetic tape (Number 001272 NYG). The first program then decoded the IBM 8 level characters and punched the converted data onto cards. This card deck was the main source of the raw data, and it provided the input data for the second program which converted the recorded voltages from the different measuring devices, using calibration curves, into temperatures, gas compositions and weight loss. This program also supplied a data card deck for the third program, which used the Stromberg-Carlson 4020 plotter to present the results graphically. The three programs and their necessary control cards will be discussed briefly below.

G.2. Punched Paper Tape Conversion Porgram (DATA REDUCTION 1). This program read data from magnetic tape and decoded the IBM 8 level characters. The program therefore essentially performed the same function as the IBM 047 paper-tape-to-card converter. The output could be obtained in a number of different formats according to control statements. The first card following the FORTRAN deck contained a number from 1 to 7 in column 2 (I-Format). The desired output format determined the selection of the number in column 2 as follows:

| Number for Column Two | Write on Disk | Punch out Cards | Print on Paper |
|---|---|---|---|
| 1 | YES | NO | NO |
| 2 | NO | YES | NO |
| 3 | YES | YES | NO |
| 4 | YES | YES | YES |
| 5 | NO | YES | YES |
| 6 | NO | NO | YES |
| 7 | YES | NO | YES |

Each output method employed an additional control following the first one. The card(s) contained the low and high channel numbers used on the Data Acquisition System in columns 2-4 and 6-8 respectively (I3-Format).

DATA REDUCTION 1 was mainly developed by Alex Tschyrkow and Siegfried Mathias, whose help is gratefully acknowledged. The FORTRAN listing of this program is given at the end of this appendix.

G.3. Voltage Conversion Program (DATA REDUCTION 2). This program converted the output from DATA REDUCTION 1 (which consisted of a set of tables of voltages from the different recording instruments, each table corresponding to each time a reading was taken) to temperatures, gas compositions and weight loss.

For the conversions, the program used the following calibration curves and tables: (a) tables of millivolt output as a function of temperature for both Chromel-Alumel and Platinum-Rhodium thermocouples, (millivolt readings between tabular points were converted using simple linear interpolation); (b) "best fit" polynomials for gas composition as a function of millivolt output for the NDIR carbon dioxide and carbon monoxide meters (the calibration curve for the oxygen meter was linear and was determined separately at the start of each run); (c) slope of the load cell calibration curve (millivolt output of load cell per volt input to bridge per lb).

DATA REDUCTION 2 supplied the following output: (a) a table of non-fuel bed thermocouple temperatures and the different times at which the readings were taken; (b) a similar table of fuel bed temperatures; (c) a table of times when the ignition front reached the position at which the thermocouple was located (five different ignition temperatures could be assumed); (d) three tables of gas compositions ($O_2$, $CO_2$, and CO), one for each probe, at the different elapsed times into the run that they were taken; (e) tabulated weight loss at the different elapsed times into the run.

This program also supplied the same reduced data output in card form suitable for input data for the third program. Help with the development of DATA REDUCTION 2 by Siegfried Mathias is gratefully acknowledged.

The following control cards were required for DATA REDUCTION 2.

| Control Card Number | Card Contents | Card Columns |
|---|---|---|
| 1 | Low Data Acquisition System channel number in the range of channels used (I-Format) | 1-5 |
| 1 | High Data Acquisition System channel number in the range of channels used (I-Format) | 6-10 |
| 1 | For Chromel-Alumel thermocouples specify a "2." For platinum-rhodium thermocouples, specify a "1" (I-Format) | 15 |

| Control Card Number | Card Contents | Card Columns |
|---|---|---|
| 1 | The thermocouple reference voltage in millivolts (I-Format) | 16-25 |
| 1 | For temperature conversion to degrees Centigrade specify a "1"; for degrees Fahrenheit, specify a "2" (I-Format) | 30 |
| 1 | The low Data Acquisition System channel number in the range of channels containing thermocouple outputs (I-Format) | 31-35 |
| 1 | The high Data Acquisition System channel number in the range of channels containing the thermocouple outputs (I-Format) -- Note: All thermocouple outputs must be grouped together. | 36-40 |
| 1 | The Data Acquisition System channel number for the event indication channel (I-Format) | 41-45 |
| 1 | The run number (I-Format) | 46-50 |
| 2 | Minimum voltage to event indication channel when red light is on (start of run) (F-Format) | 1-10 |
| 2 | Maximum voltage to event indication channel when red light is on (F-Format) | 11-20 |
| 2 | Minimum voltage to event indication channel when amber light is on (fuel bed weight; upscale calibration of $O_2$ meter) (F-Format) | 21-30 |
| 2 | Maximum voltage to event indication channel when green light is on (dead weight; downscale calibration of $O_2$ meter) (F-Format) | 41-50 |
| 2 | Maximum voltage to event indication channel when green light is on (F-Format) | 51-60 |

| Control Card Number | Card Contents | Card Columns |
|---|---|---|
| 2 | Minimum voltage to event indication channel when no lights are on (underfire air at final level) (F-Format) | 61-70 |
| 2 | Maximum voltage to event indica-channel when no lights are on (F-Format) | 71-80 |

The control cards listed below were required to be placed after the data deck from DATA REDUCTION 1. (Note: the last card before these control cards must contain "-2" in columns 1 and 2.)

| Control Card Group | Card Contents | Card Columns |
|---|---|---|
| 1 | Data Acquisition System channel number(s) (I5-Format) for which a listing of voltage(s) is required. The end of this data set is marked by putting a "-1" (I5-Format) after the last channel for which a listing is required. (If no voltage listings are required omit this card.) | 1-5, 6-10, 11-15. . . 70-75, 76-80 (use as many cards as necessary) |
| 2 | Data Acquisition System channel numbers (I5-Format) of any thermocouples, other than those in the fuel bed, for which a listing of temperatures is required. The end of the data set is marked by putting a "-1" (I5-Format) following the last channel for which a listing is required. | 1-5, 6-10, 11-15. . . 70-75, 76-80 (use as many cards as necessary) |
| 3 | Data Acquisition System channel numbers (I5-Format of any thermocouples for which a temperature-time SC4020 plot is required. Each card must contain the channels for one plot only; a maximum of 9 channels can be plotted on one plot. At the end of each set of data to be plotted put a "-1" (I5-Format) | 1-5, 6-10 11-15. . . 40-45, 46-50 |

| Control Card Group | Card Contents | Card Columns |
|---|---|---|
| 4 | "-2" (I5-Format). This signifies the end of temperature plots. | 4-5 |
| 5 | If a plot of the load cell results is required specify Data Acquisition System channels containing output voltage of and input voltage to load cell (I5-Format). If no plot is desired, or no load cell is used, specify a "-1" (I5-Format). | output 1-5<br>input 6-10 |
| 6 | Specify Data Acquisition System channel numbers (I5-Format) of the CO, CO$_2$ and O$_2$ meters and Data Acquisition System channel that contains O$_2$ meter calibration results. There must be one card for each gas sampling probe used. These control cards serve for obtaining both a listing of the gas compositions and the card output for DATA REDUCTION 3. | 1-5, 6-10, 11-15, 16-20 |
| 7 | "-1" (I5-Format). This signifies the end of gas composition plots. | 4-5 |
| 8 | Specify Data Acquisition System channel numbers, in ascending order, of the fuel bed thermocouples (I5-Format). Put a "-1" (I5-Format) after the last channel number. Specify a "-2" (I5-Format) if no ignition propagation rate is required. | 1-5, 6-10<br>. . .<br>(4-5) |
| 9 | Specify the ignition temperature(s) -- limit of five (F-Format) | 1-10, 11-20, 21-30, 31-40, 41-50 |
| 10 | Specify the number which when added to the position number of the fuel bed thermocouple gives the distance of that thermocouple from the top of the bed. For a bed that has been built to the top of the bottom section this number is 3 (F-Format). | 5 |

| Control Card Group | Card Contents | Card Columns |
|---|---|---|
| 11 | Specify the position number of the fuel bed thermocouples in ascending order (I5-Format). These numbers must correspond in card position to the channels specified in control card group 8. | 1-5, 6-10, . . . 71-75, 76-80 |

G.4. Data Plotting Program (DATA REDUCTION 3). The data deck for this program is supplied by DATA REDUCTION 2. This program uses standard SC4020 subroutines to plot the data on the Stromberg-Carlson 4020 plotter. Help with the development of this program by Siegfried Mathias is gratefully acknowledged.

The following control cards are required after the first card of the punched output of DATA REDUCTION 2.

| Card Number | Card Contents | Card Column Numbers |
|---|---|---|
| 1 | Run number (I4-Format) | 1-4 |
| 1 | Date (e.g., 01/03/71) | 6-13 |
| 2 | Weight charged (in lb) (F4.1 Format) | 1-4 |
| 3 | Bulk density of fuel ($lb/ft^3$) (F4.1 Format) | 1-4 |
| 4 | % moisture (F4.1 Format) | 1-4 |
| 5 | % wood (F4.1 Format) | 1-4 |
| 6 | % paper (F4.1 Format) | 1-4 |
| 7 | % cardboard (F4.1 Format) | 1-4 |
| 8 | % inert (F4.1 Format) | 1-4 |
| 9-13 | Specify overfire air nozzle identification letters and numbers and flow rate in scfm (e.g., WSW1, 20=20.2). Use blank cards if less than five overfire air jets were used. | 1-12 |
| 14 | If natural draft was used put a "-1" in columns 10-29. | |

| Card Number | Card Contents | Card Column Number |
|---|---|---|
| 14 | If underfire air was used put a "+1" (F-Format) and put the flow rate (scfm) in columns 1-4 and 6-9 (F4.1 Format). | |

After each group of plottable data put three cards containing the title of the plot and any other information required (49 characters per line except the thermal wave plot, which has 42 characters per line). Put the title in columns 1-80 of the data cards; if no title is required put in three blank cards.

# DATA REDUCTION 1

## Fortran Program Listing

```
      DIMENSION IEXTRA(2),ITEMP(9),ITAHL(10),IREAD(10),IREDD(10),IREED(
     110)
      INTEGER*2 ITAHL/Z2040,Z0140,Z0240,Z1340,Z0440,Z1540,Z1640,Z0740,Z0
     1840,Z1940/,FL/Z9040/
      INTEGER*2 ITCHAR(100),IEXTRA/Z1040/,ZERO,SP/Z1040/,ITEMP/9*Z2040/
      INTEGER IDISIP(3,7)/1,0,0,0,1,0,1,1,0,1,1,1,0,1,1,0,0,1,1,0,1/
      INTEGER L1/0/,L2/0/,L3/0/,N1/0/,N2/0/,N3/0/,J1/0/
      INTEGER IDUMP(200)/200*0/,IFIRST/0/
      EQUIVALENCE (IEXTRA(2),ITCHAR(1)),(ZERO,ITAHL(1))
      ICOUNT = 1
      READ(5,10) INFO,IRUN
10    FORMAT(1X,I1,3X,I5)
      IKNOW = 1
      ID=IDISIP(1,INFO)
      IS=IDISIP(2,INFO)
      IP=IDISIP(3,INFO)
20    FORMAT(2(1X,I3))
      IF(IS .NE. 1) GO TO 30
      READ(5,20) ILL,IGG
30    IF(IP .NE. 1) GO TO 40
      READ(5,20) IL3,IG3
40    READ(10,50,END=350) ITCHAR
50    FORMAT(100A1)
      DO 340 I=1,100
      INTEG=0
      IF(ITCHAR(I) .EQ. SP .AND. ITCHAR(I-1) .NE. SP .AND. ITCHAR(I-1) .
     1NE. FL) GO TO 70
      IF(ITCHAR(I) .EQ. SP .OR. ITCHAR(I) .EQ. FL) GO TO 340
      DO 60 J=1,8
      JJ=9-J
60    ITEMP(JJ+1)=ITEMP(JJ)
      ITEMP(1)=ITCHAR(I)
      GO TO 340
70    DO 80 K=1,9
      DO 80 KK=1,10
      IF(ITEMP(K) .EQ. ITAHL(KK)) INTEG=INTEG +(KK-1)*10**(K-1)
80    CONTINUE
      IF(INTEG .GT. 9000000 .OR. INTEG .LT. 8000000) GO TO 190
      J1=0
      IF(N2 .EQ. 0) GO TO 100
      DO 90 JJ2 = 2, N2, 2
      CALL FIXUP(IREDD(JJ2))
      IDUMP(ICOUNT) = IREDD(JJ2)
90    ICOUNT = ICOUNT + 1
      N2=0
100   IF(N1 .EQ. 0) GO TO 110
      N1=0
110   IF (N3 .EQ. 0) GO TO 130
      WRITE(6,120) (IREAD(M),M=1,N3)
120   FORMAT(5(1X,I3,I10))
      N3=0
130   IF(IFIRST - 1)170,140,170
140   ITOTAL = ICOUNT - 1
      DO 150 JJ2 = 1, ITOTAL, 9
      JJHIGH = JJ2 + 8
      WRITE(7,160) (IDUMP(JJ3),JJ3=JJ2,JJHIGH),IRUN,IKNOW
150   IKNOW = IKNOW + 1
160   FORMAT(9I8,I3,I5)
170   IFIRST = 1
      ICOUNT = 1
      IDUMP(ICOUNT) = INTEG
      ICOUNT = ICOUNT + 1
      IF(IP .EQ. 1) WRITE(6,180) INTEG
180   FORMAT(5X,I8)
      GO TO 320
```

```
190   J1=J1+1                                                          MAIN0660
      K=2*(J1/2.-J1/2)+.5                                              MAIN0670
      IF(K .EQ. 0) GO TO 250                                           MAIN0680
      IF(ID .NE. 1) GO TO 210                                          MAIN0690
      IF(INTEG .LT. IL .OR. INTEG .GT. IG) GO TO 200                   MAIN0700
      L1=1                                                             MAIN0710
      GO TO 210                                                        MAIN0720
200   L1=0                                                             MAIN0730
210   IF(IS .NE. 1) GO TO 230                                          MAIN0740
      IF(INTEG .LT. ILL .OR. INTEG .GT. IGG) GO TO 220                 MAIN0750
      L2=2                                                             MAIN0760
      GO TO 230                                                        MAIN0770
220   L2=0                                                             MAIN0780
230   IF(IP .NE. 1) GO TO 250                                          MAIN0790
      IF(INTEG .LT. IL3 .OR. INTEG .GT. IG3) GO TO 240                 MAIN0800
      L3=3                                                             MAIN0810
      GO TO 250                                                        MAIN0820
240   L3=0                                                             MAIN0830
250   IF(ID .NE. 1 .OR. L1 .NE. 1) GO TO 270                           MAIN0840
      N1=N1+1                                                          MAIN0850
      IREED(N1)=INTEG                                                  MAIN0860
      IF(N1 .EQ. 10) GO TO 260                                         MAIN0870
      GO TO 270                                                        MAIN0880
260   CONTINUE                                                         MAIN0890
      N1=0                                                             MAIN0900
270   IF(IS .NE. 1 .OR. L2 .NE. 2) GO TO 300                           MAIN0910
      N2=N2+1                                                          MAIN0920
      IREDD(N2)=INTEG                                                  MAIN0930
      IF(N2 .EQ. 10) GO TO 280                                         MAIN0940
      GO TO 300                                                        MAIN0950
280   DO 290 JJ2 = 2, N2, 2                                            MAIN0960
      CALL FIXUP(IREDD(JJ2))                                           MAIN0970
      IDUMP(ICOUNT) = IREDD(JJ2)                                       MAIN0980
290   ICOUNT = ICOUNT + 1                                              MAIN0990
      N2= 0                                                            MAIN1000
300   IF(IP .NE. 1 .OR. L3 .NE. 3) GO TO 320                           MAIN1010
      N3=N3+1                                                          MAIN1020
      IREAD(N3)=INTEG                                                  MAIN1030
      IF(N3 .EQ. 10) GO TO 310                                         MAIN1040
      GO TO 320                                                        MAIN1050
310   WRITE(6,120) (IREAD(M),M=1,N3)                                   MAIN1060
      N3=0                                                             MAIN1070
320   DO 330 K=1,9                                                     MAIN1080
330   ITEMP(K) =ZERO                                                   MAIN1090
340   CONTINUE                                                         MAIN1100
      IEXTRA(1)=ITCHAR(100)                                            MAIN1110
      GO TO 40                                                         MAIN1120
350   IEND=-2                                                          MAIN1130
360   FORMAT(1X,I2,69X,I3,I5)                                          MAIN1140



      IF(IS .EQ. 1) GO TO 370                                          MAIN1150
      GO TO 410                                                        MAIN1160
370   IF(N2 .EQ. 0) GO TO 400                                          MAIN1170
      DO 380 JJ2 = 2, N2, 2                                            MAIN1180
      CALL FIXUP(IREDD(JJ2))                                           MAIN1190
      IDUMP(ICOUNT) = IREDD(JJ2)                                       MAIN1200
380   ICOUNT = ICOUNT + 1                                              MAIN1210
      ITOTAL = ICOUNT - 1                                              MAIN1220
      DO 390 JJ2 = 1, ITOTAL, 9                                        MAIN1230
      JJHIGH = JJ2 + 8                                                 MAIN1240
      WRITE(7,150) (IDUMP(JJ3),JJ3 = JJ2,JJHIGH),IRUN,IKNOW            MAIN1250
390   IKNOW = IKNOW + 1                                                MAIN1260
400   WRITE(7,360) IEND,IRUN,IKNOW                                     MAIN1270
410   IF(IP .EQ. 1) GO TO 420                                          MAIN1280
      GO TO 440                                                        MAIN1290
420   IF(N3 .EQ. 0) GO TO 430                                          MAIN1300
      WRITE(6,120) (IREAD(M),M=1,N3)                                   MAIN131/
430   WRITE(6,360) IEND                                                MAIN1320
440   STOP                                                             MAIN1330
      END                                                              MAIN1340
      SUBROUTINE FIXUP(I)                                              FIXP0010
      IF(I- 100000000)20,10,10                                         FIXP0020
10    I= I- 90000000                                                   FIXP0030
20    RETURN                                                           FIXP0040
      END                                                              FIXP0050
```

# DATA REDUCTION 2

## Fortran Program Listing

```
      [illegible]                                                       MAIN0010
     1[illegible]                                                       MAIN0020
      INTEGER CHAN,[illegible],SWITCH                                   MAIN0030
      DIMENSION DUMY(9)                                                 MAIN0040
      READ(5,670) ICN                                                   MAIN0050
      IKNOW = 1                                                         MAIN0060
      DO 10 JJ=1,600                                                    MAIN0070
      DO 10 II=1,60                                                     MAIN0080
10    VOLTS(JJ,II) = 0.                                                 MAIN0090
20    READ(5,580) JCHL ,JCHH,[illegible]                                MAIN0100
     1 ,SWITCH,IRUN                                                     MAIN0110
      READ(5,570) [illegible]                                           MAIN0120
      COUNT = JCHH - JCHL + 1                                           MAIN0130
      DO 30 II=1,COUNT                                                  MAIN0140
      CHAN(II)=JCHL +II-1                                               MAIN0150
30    CONTINUE                                                          MAIN0160
      I=0                                                               MAIN0170
40    I=I+1                                                             MAIN0180
      I2=0                                                              MAIN0190
      READ(5,590) ITIME(I),(DUMY(II),II=1,8),ICARD                      MAIN0200
      TIME(I) = ITIME(I)        - 8000000                               MAIN0210
      TIME(I) = TIME(I) / 100.                                          MAIN0220
      IF(ITIME(I))270,270,50                                            MAIN0230
50    IF(ITIME(I) .LT. 8000000 .OR. ITIME(I) .GT. 9000000) GO TO 70     MAIN0240
      ITIME(I) = ITIME(I) - 8000000                                     MAIN0250
      GO TO 130                                                         MAIN0260
60    WRITE(6,610) ICARD                                                MAIN0270
      GO TO 730                                                         MAIN0280
70    WRITE(6,630) ICARD                                                MAIN0290
      GO TO 730                                                         MAIN0300
80    READ(5,590) ITEST,(DUMY(II),II=2,9),ICARD                         MAIN0310
      IF(ITEST)270,270,90                                               MAIN0320
90    IF(ITEST .LT. 8000000 .OR. ITEST .GT. 9000000) GO TO 150          MAIN0330
      DO 100 JJ=1,8                                                     MAIN0340
100   DUMY(JJ)=DUMY(JJ+1)                                               MAIN0350
      I=I+1                                                             MAIN0360
      IF(COUNT - 12)120,120,110                                         MAIN0370
110   I = I - 1                                                         MAIN0380
      WRITE(6,620) ICARD                                                MAIN0390
120   I2=0                                                              MAIN0400
      ITIME(I) = ITEST - 8000000                                        MAIN0410
      TIME(I) = (ITEST-8000000)                                         MAIN0420
      TIME(I) = TIME(I) /  100.                                         MAIN0430
130   IEND = 1                                                          MAIN0440
      DO 140 JJ = 1, 8                                                  MAIN0450
      IF(DUMY(JJ  ))160,170,140                                         MAIN0460
140   IEND = JJ                                                         MAIN0470
      GO TO 170                                                         MAIN0480
150   DUMY(1) = ITEST                                                   MAIN0490
      DUMY(1) = DUMY(1) / 1000000.                                      MAIN0500
      IEND = 1                                                          MAIN0510
      DO 160 JJ=2,9                                                     MAIN0520
      IF (DUMY(JJ))160,170,160                                          MAIN0530
160   IEND=JJ                                                           MAIN0540
170   DO 220 JJ=1,IEND                                                  MAIN0550
      I2=I2+1                                                           MAIN0560
      IF(I-600)190,190,180                                              MAIN0570
180   WRITE(6,640)                                                      MAIN0580
      GO TO 730                                                         MAIN0590
190   IF(I2-60)210,210,200                                              MAIN0600
200   WRITE(6,650)                                                      MAIN0610
      GO TO 730                                                         MAIN0620
210   VOLTS(I,I2)=DUMY(JJ)                                              MAIN0630
220   CONTINUE                                                          MAIN0640
      IP=I                                                              MAIN0650
      IF(I-3)230,230,240                                                MAIN0660
230   I2P=I2                                                            MAIN0670
240   IF(IEND-8)250,80,80                                               MAIN0680
250   IF(COUNT - 12)40,40,260                                           MAIN0690
260   I = I - 1                                                         MAIN0700
      GO TO 40                                                          MAIN0710
270   IF((I2P/9)*9-I2P)280,290,280                                      MAIN0720
280   IP= I - 1                                                         MAIN0730
290   DO 310 JJ=1,IP                                                    MAIN0740
      DO 300 II=1,I2P                                                   MAIN0750
      CALL FIXIT(VOLTS(JJ,II))                                          MAIN0760
300   CONTINUE                                                          MAIN0770
310   CONTINUE                                                          MAIN0780
      SWITCH = SWITCH - JCHL + 1                                        MAIN0790
      WRITE(7,660) IP, I2P, ICONF,IRUN,IKNOW                            MAIN0800
      IKNOW = IKNOW + 1                                                 MAIN0810
      DO 320 JJ = 1, IP                                                 MAIN0820
320   VOLTS(JJ,SWITCH) = ABS(VOLTS(JJ,SWITCH))                          MAIN0830
      DO 330 JJ = 1, IP                                                 MAIN0840
      NOW = JJ                                                          MAIN0850
      IF(VOLTS(JJ,SWITCH).GT.GNDLO ).AND.VOLTS(JJ,SWITCH).LT.GNDHI ) GO TOMAIN0860
     1 340                                                              MAIN0870
330   CONTINUE                                                          MAIN0880
340   DO 350 JJ = 1, IP                                                 MAIN0890
      NAW = JJ                                                          MAIN0900
      IF(VOLTS(JJ,SWITCH).GT.AMPLO).AND.VOLTS(JJ,SWITCH).LT.AMPHI ) GO TOMAIN0910
     1 360                                                              MAIN0920
350   CONTINUE                                                          MAIN0930
360   DO 370 JJ=1,IP                                                    MAIN0940
      NOFF=JJ                                                           MAIN0950
      IF(VOLTS(JJ,SWITCH).GT.OFFLO ).AND.VOLTS(JJ,SWITCH).LT.OFFHI ) GO TOMAIN0960
     1 380                                                              MAIN0970
370   CONTINUE                                                          MAIN0980
380   DO 390 JJ = 1, IP                                                 MAIN0990
      NSIG = JJ                                                         MAIN1000
      IF(VOLTS(JJ,SWITCH).GT.REFLO ).AND.VOLTS(JJ,SWITCH).LT.REFHI ) GO TOMAIN1010
     1 400                                                              MAIN1020
390   CONTINUE                                                          MAIN1030
400   DO 410 JJ=NSIG,IP                                                 MAIN1040
      NOFF1=JJ                                                          MAIN1050
      IF(VOLTS(JJ,SWITCH).GT.OFFLO ).AND.VOLTS(JJ,SWITCH).LT.OFFHI ) GO TOMAIN1060
      1 42)                                                            MAIN1070
  410 CONTINUE                                                         MAIN1080
  420 WRITE(6,680) IRUN                                                MAIN1090
      WRITE(6,690) TIME(KSIG)                                          MAIN1100
      WRITE(6,720) TIME(KOFF1)                                         MAIN1110
      DIV=KBW-KOW                                                      MAIN1120
      DIV1=KOFF-KBW                                                    MAIN1130
      WRITE(6,700) DIV                                                 MAIN1140
      WRITE(6,710) DIV1                                                MAIN1150
      WRITE(6,570) KOW,KBW,KSIG,TIME(KOW),TIME(KBW),TIME(KSIG)         MAIN1160
      GO TO (430,440),PRINT                                            MAIN1170
  430 WRITE(6,560)                                                     MAIN1180
      CALL MYLST(1,KSIG,I2P)                                           MAIN1190
  440 TEMLO = TEMLO - JCHLC + 1                                        MAIN1200
      TEMHI = TEMHI - JCHLC + 1                                        MAIN1210
      DO 460 JJ=1,IP                                                   MAIN1220
      DO 450 II=TEMLO, TEMHI                                           MAIN1230
      VOLTS(JJ,II)=1000.*VOLTS(JJ,II)                                  MAIN1240
      CALL TCHRA (VOLTS(JJ,II),REF,DUM )                               MAIN1250
      VOLTS(JJ,II)=DUM                                                 MAIN1260
  450 CONTINUE                                                         MAIN1270
  460 CONTINUE                                                         MAIN1280
      IF(ICONF-1)490,490,470                                           MAIN1290
  470 DO 480 JJ=1, IP                                                  MAIN1300
      DO 480 II = TEMLO, TEMHI                                         MAIN1310
  480 VOLTS(JJ,II) = VOLTS(JJ,II) * 1.8 + 32.                          MAIN1320
      WRITE(6,550)                                                     MAIN1330
      GO TO  500                                                       MAIN1340
  490 WRITE(6,540)                                                     MAIN1350
  500 WRITE(6,530)                                                     MAIN1360
      WRITE(6,520) REF                                                 MAIN1370
      CALL MYLST(1, KSIG,I2P)                                          MAIN1380
      CALL MYPLT(KSIG,I2P)                                             MAIN1390
      CALL WEIGHT(KSIG,JCHLO,KOW,KBW,KOFF)                             MAIN1400
      CALL AIR(KSIG,JCHLO,KOW,KBW,KOFF)                                MAIN1410
      WRITE(6,510)                                                     MAIN1420
      WRITE(6,530)                                                     MAIN1430
      WRITE(6,520) REF                                                 MAIN1440
      CALL MYLST(2,KSIG,I2P)                                           MAIN1450
      GO TO (20,730),IEND                                              MAIN1460
  510 FORMAT('1',52X,'FUEL BED TEMPERATURES'////)                      MAIN1470
  520 FORMAT(' THE REFERENCE VOLTAGE IN MILLIVOLTS IS',F10.5,/)        MAIN1480
  530 FORMAT(' FROM THE CHROMEL-ALUMEL TABLE',/)                       MAIN1490
  540 FORMAT(' TABLE OF TEMPERATURES IN DEG CENTIGRADE',/)             MAIN1500
  550 FORMAT('1',30X,'TABLE OF TEMPERATURES (EXCLUDING FUEL BED) IN DEG.MAIN1510
     1 FAHRENHEIT'///)                                                 MAIN1520
  560 FORMAT('1',45X,'TABLE OF VOLTAGES'///)                           MAIN1530
  570 FORMAT(///,1X,'INDICATION CHANNEL LIGHT GREEN, AMBER AND RED (NUMBMAIN1540
     1ER) AND TIME (',I3,',',I3,',',I3,')'-3E14.6,//)                  MAIN1550
  580 FORMAT(3I5,F10.5,6I5)                                            MAIN1560
  590 FORMAT(I8,8F8.6,4X,I4)                                           MAIN1570
  600 FORMAT(//,' TIME CARD ERROR PROGRAM TERMINATED AT CARD',I6,//)   MAIN1580
  610 FORMAT(//,'      NEG READING IN DATA SET PROGRAM TERMINATED AT CARDMAIN1590
     1',I6,//)                                                         MAIN1600
  620 FORMAT(//,' CHAN COUNT ERROR DATA SET ELIMINATED CARD ',I6,//)   MAIN1610
  630 FORMAT(8F10.5)                                                   MAIN1620
  640 FORMAT(//,' TOO MANY READINGS PROGRAM TERMINATED',//)            MAIN1630
  650 FORMAT(//,' TOO MANY CHANNELS PROGRAM TERMINATED',//)            MAIN1640
  660 FORMAT(3I5,52X,I3,I5)                                            MAIN1650
  670 FORMAT(F4.0,15F5.0)                                              MAIN1670
  680 FORMAT('1',///,49X,'RUN NUMBER = ',I2,//)                        MAIN1680
  690 FORMAT(40X,'RUN STARTED AT TIME = ',E14.6,///)                   MAIN1690
  700 FORMAT(12X,'NUMBER OF READINGS OF 0 PERCENT O2 AND DEAD WT. = ',  MAIN1700
     1 F5.1,/)                                                         MAIN1710
  710 FORMAT(10X,'NUMBER OF READINGS OF 21 PERCENT O2 AND TOTAL WT. = ',MAIN1720
     1 F5.1,/)                                                         MAIN1730
  720 FORMAT(22X,' UNDERFIRE AIR AT FINAL VALUE AT TIME = ',E14.6,/)   MAIN1740
  730 STOP                                                             MAIN1750
      END                                                              MAIN1760
```

```
      SUBROUTINE MYLST(ITYME,KSIG,I2P)                                 MYLT0010
      COMMON/SIG/VOLTS(600,60),CHAN(60),COUNT,IP,TIME(600),IRUN,IKNOW  MYLT0020
     1/SIG1/TYME(5,60),DEPTH(300),COMNT(300),XX2(150),YY2(150)         MYLT0030
     2,TCDPTH(600)                                                     MYLT0040
      INTEGER CHAN,TCDPTH,WHATP(150)                                   MYLT0050
      DIMENSION TEST(5)                                                MYLT0060
      LOLO = 1                                                         MYLT0070
      TMAX = 0.                                                        MYLT0080
   10 LHIHI = LOLO + 15                                                MYLT0090
      READ(5,390) (WHATP(JJ),JJ=LOLO,LHIHI)                            MYLT0100
      GO TO (30,20) ,ITYME                                             MYLT0110
   20 WRITE(7,400) (WHATP(JJ),JJ=LOLO,LHIHI),IRUN,IKNOW                MYLT0120
      IKNOW = IKNOW + 1                                                MYLT0130
   30 DO 80 JJ=LOLO,LHIHI                                              MYLT0140
      IF(WHATP(JJ) + 1)70,70,40                                        MYLT0150
   40 DO 60 II=1,I2P                                                   MYLT0160
      IF(CHAN(II)-WHATP(JJ))60,50,60                                   MYLT0170
   50 WHATP(JJ) = II                                                   MYLT0180
      GO TO 80                                                         MYLT0190
   60 CONTINUE                                                         MYLT0200
      WRITE(6,380) WHATP(JJ)                                           MYLT0210
      WHATP(JJ) = 1                                                    MYLT0220
      GO TO 80                                                         MYLT0230
   70 LHI = JJ - 1                                                     MYLT0240
      GO TO 90                                                         MYLT0250
   80 CONTINUE                                                         MYLT0260
      LOLO = LHIHI + 1                                                 MYLT0270
      GO TO 10                                                         MYLT0280
   90 DO 100 KK=LHI,30                                                 MYLT0290
  100 WHATP(KK+1) = 1                                                  MYLT0300
```

```
      DO 120 JJ= 1, LHI,                                                MYLT0310
       JJ1 = WHATP(JJ)                                                  MYLT0320
       JJ2 = WHATP(JJ+1)                                                MYLT0330
       JJ3 = WHATP(JJ+2)                                                MYLT0340
       JJ4 = WHATP(JJ+3)                                                MYLT0350
       JJ5 = WHATP(JJ+4)                                                MYLT0360
       JJ6 = WHATP(JJ+5)                                                MYLT0370
       JJ7 = WHATP(JJ+6)                                                MYLT0380
       JJ8 = WHATP(JJ+7)                                                MYLT0390
       WRITE(6,370) CHAN(JJ1),CHAN(JJ2),CHAN(JJ3),CHAN(JJ4),CHAN(JJ5),  MYLT0400
     1  CHAN(JJ6),CHAN(JJ7),CHAN(JJ8)                                   MYLT0410
       DO 110 KK=KSIG,IP                                                MYLT0420
110    WRITE(6,360) TIME(KK),VOLTS(KK,JJ1),VOLTS(KK,JJ2),VOLTS(KK,JJ3), MYLT0430
     1 VOLTS(KK,JJ4),VOLTS(KK,JJ5),VOLTS(KK,JJ6),VOLTS(KK,JJ7)          MYLT0440
     2,VOLTS(KK,JJ8)                                                    MYLT0450
120    CONTINUE                                                         MYLT0460
       GO TO (270,130) ,ITYM                                            MYLT0470
130    READ(5,350) (TEST(III) ,III=1,5)                                 MYLT0480
       WRITE(7,340) (TEST(I),I=1,5),IRUN,IKNOW                          MYLT0490
       IKNOW = IKNOW + 1                                                MYLT0500
       IF(TEST(1))270 ,140,140                                          MYLT0510
140    DEPTH(298) = TIME(KSIG)                                          MYLT0520
       ITEST = 0                                                        MYLT0530
       READ(5,330) XDEEP                                                MYLT0540
       READ(5,390) (TCDPTH(JJ),JJ = 1, LHI)                             MYLT0550
       DO 150 JJ = 1, LHI                                               MYLT0560
       DEPTH(JJ) = TCDPTH(JJ)                                           MYLT0570
150    DEPTH(JJ) = DEPTH(JJ) + XDEEP                                    MYLT0580
       JJ2 = 298                                                        MYLT0590
       DO 170 JJ=1,5                                                    MYLT0600
       IF(TEST(JJ))170,170,160                                          MYLT0610
160    ITEST = JJ                                                       MYLT0620
170    CONTINUE                                                         MYLT0630
       DO 180 JJ=1,LHI                                                  MYLT0640
       DO 180 KK=1,5                                                    MYLT0650
180    TYME(KK,JJ) = -10.                                               MYLT0660
       DO 230 II500=1,ITEST                                             MYLT0670
       DO 220 II=1,LHI                                                  MYLT0680
       DO 190 JJ=KSIG,IP                                                MYLT0690
       I9 = WHATP(II)                                                   MYLT0700
       IF(VOLTS(JJ,I9)-TEST(II500))190,200,200                          MYLT0710
190    CONTINUE                                                         MYLT0720
       TYME(II500,II)=0.0                                               MYLT0730
       GO TO 220                                                        MYLT0740
200    DEPTH(299) = TIME(JJ-1)                                          MYLT0750
       DEPTH(300) = TIME(JJ)                                            MYLT0760
       DO 210 JJ1 = JJ2, 300                                            MYLT0770
       IHRS=DEPTH(JJ1)/100.                                             MYLT0780
       RHRS=IHRS*100                                                    MYLT0790
       IMIN=DEPTH(JJ1)-RHRS                                             MYLT0800
       RMIN=IMIN                                                        MYLT0810
       ISEC=(DEPTH(JJ1)-RHRS-RMIN)*100.                                 MYLT0820
210    DEPTH(JJ1)=IHRS*3600+IMIN*60+ISEC                                MYLT0830
       JJ2 = 299                                                        MYLT0840
       TYME(II500,II) = (DEPTH(299)-DEPTH(300))/(VOLTS(JJ-1,I9)         MYLT0850
     1-VOLTS(JJ,I9))*                                                   MYLT0860
     2 (TEST(II500)-VOLTS(JJ,I9))+DEPTH(300) - DEPTH(298)               MYLT0870
220    CONTINUE                                                         MYLT0880
230    CONTINUE                                                         MYLT0890
       DO 240 JJ3 = 1, ITEST                                            MYLT0900
       WRITE(6,310)                                                     MYLT0910
       WRITE(6,320)                                                     MYLT0920
       DO 240 JJ4 = 1, LHI                                              MYLT0930
240    WRITE(6,300) DEPTH(JJ4),TYME(JJ3,JJ4),TEST(JJ3)                  MYLT0940
       WRITE(7,290) ITEST,LHI,TMAX,IRUN,IKNOW                           MYLT0950
       IKNOW = IKNOW + 1                                                MYLT0960
       DO 250 JJ = 1, LHI, 12                                           MYLT0970
       JJHIGH = JJ + 11                                                 MYLT0980
       WRITE(7,280) (DEPTH(KK),KK=JJ,JJHIGH),IRUN,IKNOW                 MYLT0990
250    IKNOW = IKNOW + 1                                                MYLT1000
       DO 260 JJ = 1, ITEST                                             MYLT1010
       DO 260 KK = 1, LHI, 12                                           MYLT1020
       KKHIGH = KK + 11                                                 MYLT1030
       WRITE(7,280) (TYME(JJ, KK1), KK1= KK,KKHIGH),IRUN,IKNOW          MYLT1040
260    IKNOW = IKNOW + 1                                                MYLT1050
270    RETURN                                                           MYLT1060
280    FORMAT(12F6.1,I3,I5)                                             MYLT1070
290    FORMAT(2I5,F20.10,42X,I3,I5)                                     MYLT1080
300    FORMAT(3(E20.6))                                                 MYLT1090
310    FORMAT('1',20X,'IGNITION WAVE PROPAGATION',//)                   MYLT1100
320    FORMAT(/' DEPTH IN INCHES         TIME IN SECONDS    TEMPERATURE INMYLT1110
     1 FAHRENHEIT')                                                     MYLT1120
330    FORMAT(F10.5)                                                    MYLT1130
340    FORMAT(5F6.1,42X,I3,I5)                                          MYLT1140
350    FORMAT(5F10.5)                                                   MYLT1150
360    FORMAT(1X,9(E14.6))                                              MYLT1160
370    FORMAT(//'       TIME',5X,8(5X,I5,4X))                           MYLT1170
380    FORMAT(' YOU HAVE SPECIFIED THAT A CHANNEL BE LISTED WHICH WAS NOTMYLT1180
     1 FED INTO THIS PROGRAM I.E. CHAN',I5)                             MYLT1190
390    FORMAT(16I5)                                                     MYLT1200
400    FORMAT(16I4,8X,I3,I5)                                            MYLT1210
       END                                                              MYLT1220
```

```
       SUBROUTINE MYPLT(KSIG,I2P)                                       MYPT0010
       COMMON/SIG/VOLTS(600,60),CHAN(60),COUNT,IP,TIME(600),IRUN,IKNOW  MYPT0020
     1/SIG1/CPX(600),CRY(600),ITIMFE(600)                               MYPT0030
     2/WAIT/OUT(600,10),COMAT(60),IP1,IP2                               MYPT0040
       INTEGER CHAN,WHATP(70)                                           MYPT0050
       IKNOW = IKNOW + 1                                                MYPT0060
```

```
      DO 10 JJ = 1, 600                                                  MVPT0070
      DO 10 KK=1,10                                                      MVPT0080
10    OUT(JJ,KK) = 0.                                                    MVPT0090
20    READ(5,240) (WHATP(JJ),JJ=1,10)                                    MVPT0100
      WRITE(7,250) (WHATP(JJ),JJ=1, 10),IRUN,IKNOW                       MVPT0110
      IKNOW = IKNOW + 1                                                  MVPT0120
      DO 90 JJ=1,10                                                      MVPT0130
      IF(WHATP(JJ)+1)180,40,30                                           MVPT0140
30    DO 50 II=1,IP                                                      MVPT0150
      IF(CHAN(II)-WHATP(JJ))50,40,50                                     MVPT0160
40    WHATP(JJ) = II                                                     MVPT0170
      GO TO 90                                                           MVPT0180
50    CONTINUE                                                           MVPT0190
      WRITE(6,230) WHATP(JJ)                                             MVPT0200
      IF(JJ-1)60,60,70                                                   MVPT0210
60    WHATP(1) = 2                                                       MVPT0220
70    WHATP(JJ) = WHATP(1)                                               MVPT0230
      GO TO 90                                                           MVPT0240
80    LHI = JJ-1                                                         MVPT0250
      GO TO 100                                                          MVPT0260
90    CONTINUE                                                           MVPT0270
      WRITE(6,220)                                                       MVPT0280
      GO TO 20                                                           MVPT0290
100   DO 110 KK=LHI,9                                                    MVPT0300
110   WHATP(KK+1) = WHATP(1)                                             MVPT0310
      JJ1 = WHATP(1)                                                     MVPT0320
      JJ2 = WHATP(2)                                                     MVPT0330
      JJ3 = WHATP(3)                                                     MVPT0340
      JJ4 = WHATP(4)                                                     MVPT0350
      JJ5 = WHATP(5)                                                     MVPT0360
      JJ6 = WHATP(6)                                                     MVPT0370
      JJ7 = WHATP(7)                                                     MVPT0380
      JJ8 = WHATP(8)                                                     MVPT0390
      JJ9 = WHATP(9)                                                     MVPT0400
      WRITE(7,210) KSIG, LHI,IRUN,IKNOW                                  MVPT0410
      IKNOW = IKNOW + 1                                                  MVPT0420
      DO 140 KK = KSIG, IP                                               MVPT0430
      IHRS = ITIMEE(KK) / 10000                                          MVPT0440
      IMIN = ITIMEE(KK) / 100 - IHRS * 100                               MVPT0450
      ISEC = ITIMEE(KK) - IHRS * 10000 - IMIN * 100                      MVPT0460
      OUT(KK,1) = IHRS*3600 + IMIN * 60 + ISEC                           MVPT0470
      OUT(KK,2) = VOLTS(KK,JJ1)                                          MVPT0480
      OUT(KK,3) = VOLTS(KK,JJ2)                                          MVPT0490
      OUT(KK,4) = VOLTS(KK,JJ3)                                          MVPT0500
      OUT(KK,5) = VOLTS(KK,JJ4)                                          MVPT0510
      OUT(KK,6) = VOLTS(KK,JJ5)                                          MVPT0520
      OUT(KK,7) = VOLTS(KK,JJ6)                                          MVPT0530
      OUT(KK,8) = VOLTS(KK,JJ7)                                          MVPT0540
      OUT(KK,9) = VOLTS(KK,JJ8)                                          MVPT0550
      OUT(KK,10) = VOLTS(KK,JJ9)                                         MVPT0560
      DO 130 JJ=2, 10                                                    MVPT0570
      IF(OUT(KK,JJ))120,120,130                                          MVPT0580
120   OUT(KK,JJ) =-10                                                    MVPT0590
130   CONTINUE                                                           MVPT0600
140   CONTINUE                                                           MVPT0610
      KSIG2 = KSIG + 1                                                   MVPT0620
      DO 150 JJ = KSIG2, IP                                              MVPT0630
150   OUT(JJ,1) = OUT(JJ,1) - OUT(KSIG ,1)                               MVPT0640
      OUT(KSIG ,1) = 0.                                                  MVPT0650
      DO 160 JJ = KSIG, IP, 12                                           MVPT0660
      KHIGH = JJ + 11                                                    MVPT0670
      WRITE(7,200) (OUT(JJ1,1),JJ1=JJ,KHIGH),IRUN,IKNOW                  MVPT0680
160   IKNOW = IKNOW + 1                                                  MVPT0690
      WRITE(7,190) IRUN,IKNOW                                            MVPT0700
      IKNOW = IKNOW + 1                                                  MVPT0710
      LHI2 = LHI + 1                                                     MVPT0720
      DO 170 KK = 2, LHI2                                                MVPT0730
      DO 170 JJ = KSIG, IP, 12                                           MVPT0740
      KHIGH = JJ + 11                                                    MVPT0750
      WRITE(7,200) (OUT(JJ1,KK),JJ1 = JJ,KHIGH), IRUN, IKNOW             MVPT0760
170   IKNOW = IKNOW + 1                                                  MVPT0770
      GO TO 20                                                           MVPT0780
180   RETURN                                                             MVPT0790
190   FORMAT('01',70X,I3,I5)                                             MVPT0800
200   FORMAT(12F6.1,I3,I5)                                               MVPT0810
210   FORMAT(2I5,62X,I3,I5)                                              MVPT0820
220   FORMAT(' THE MINUS 1 AT THE END OF THE DATA IS MISSING. NO PLOT FOMVPT0830
     1R THIS DATA')                                                      MVPT0840
230   FORMAT(' YOU HAVE SPECIFIED THAT A CHANNEL BE PLOTTED WHICH WAS NOMVPT0850
     1T FED INTO THIS PROGRAM I.E. CHAN',I5)                             MVPT0860
240   FORMAT(10I5)                                                       MVPT0870
250   FORMAT(10I5,22X,I3,I5)                                             MVPT0880
      END                                                                MVPT0890
```

```
      SUBROUTINE WEIGHT(KSIG,JCHLO,ISTART,ISTAR2,ISTAR3)                 WEIT0010
      COMMON/SIG/VOLTS(600,60),CHAN(60),COUNT,IP,TIME(600),IRUN,IKNOW    WEIT0020
     1/SIG1/X(600),Y(600),ITIMEE(600)                                    WEIT0030
     2/WAIT/OUT(600,10),CUMAT(60),IP1,IP2                                WEIT0040
      INTEGER V                                                          WEIT0050
      DO 10 KK=2,10                                                      WEIT0060
      DO 10 JJ = 1, 600                                                  WEIT0070
10    OUT(JJ,KK) = 0.                                                    WEIT0080
      READ(5,140) MV, V                                                  WEIT0090
      WRITE(7,130) MV,IRUN,IKNOW                                         WEIT0100
      IKNOW = IKNOW + 1                                                  WEIT0110
      IF(MV)70,20,20                                                     WEIT0120
20    MV = MV - JCHLO + 1                                                WEIT0130
      V = V - JCHLO + 1                                                  WEIT0140
      SUM = 0.                                                           WEIT0150
      SUMV = 0.                                                          WEIT0160
      KOUN=ISTAR3-1                                                      WEIT0170
      DO 30 JJ = ISTAR2, KOUM1                                          WEIT0180
      SUM = VOLTS(JJ,MV) + SUM                                          WEIT0190
30    SUMV = VOLTS(JJ,V) + SUMV                                         WEIT0200
      SUM = SUM/(SUMV*3.004E-6)                                         WEIT0210
      AMAX = 0.                                                         WEIT0220
      DO 40 JJ = KSIG,IP                                                WEIT0230
      OUT(JJ,2) = SUM - VOLTS(JJ,MV)/(VOLTS(JJ,V)*3.004E-6)             WEIT0240
      IF( (1000.-OUT(JJ,2))*(OUT(JJ,2)+99.)) 35,35,40                   WEIT0250
35    OUT(JJ,2) = 0.                                                    WEIT0260
40    CONTINUE                                                          WEIT0270
      DO 50 KK = KSIG, IP, 12                                           WEIT0280
      KHIGH = KK + 11                                                   WEIT0290
      WRITE(7,120) (OUT(JJ,2), JJ = KK, KHIGH), IRUN, IKNOW             WEIT0300
50    IKNOW = IKNOW + 1                                                 WEIT0310
      WRITE(6,90)                                                       WEIT0320
      WRITE(6,100)                                                      WEIT0330
      WRITE(6,110) (OUT(JW,1),OUT(JW,2),JW=KSIG,IP)                     WEIT0340
      SUMRW = 0.                                                        WEIT0350
      SUMVRW = 0.                                                       WEIT0360
      KOUM2 = ISTAR2 - 1                                                WEIT0370
      DO 60 JJ = ISTART, KOUM2                                          WEIT0380
      SUMRW = SUMRW + VOLTS(JJ, MV)                                     WEIT0390
60    SUMVRW = SUMVRW + VOLTS(JJ, V)                                    WEIT0400
      SUMRW = SUMRW/(SUMVRW * 3.004E-6)                                 WEIT0410
      REDWT = SUM - SUMRW                                               WEIT0420
      WRITE(6,80) REDWT, SUM, SUMRW                                     WEIT0430
70    RETURN                                                            WEIT0440
80    FORMAT(//' THE FUEL WEIGHT IS',F10.4,' LBS.'/' THE FULL AND EMPTY WEIT0450
     1FUEL RED SECTION WEIGHTS ARE',2F15.3,'LBS.')                      WEIT0460
90    FORMAT('1',///,32X,'SLOPE OF LOAD CELL CALIBRATION CURVE = 0.00300WEIT0470
     14 MV/V/LB',///)                                                   WEIT0480
100   FORMAT(    ///40X,'WEIGHT LOSS IN LBS, TIME IN SECONDS'           WEIT0490
     1                               ///4('     TIME',10X,'POUNDS',3X)) WEIT0500
110   FORMAT(1X,8F14.6)                                                 WEIT0510
120   FORMAT(12F6.2,I3,I5)                                              WEIT0520
130   FORMAT(I5,67X,I3,I5)                                              WEIT0530
```

```
      SUBROUTINE AIR(KSIG,JCHLO,ISTART,ISTAR2,ISTAR3)                   AIR 0010
      COMMON/SIG/VOLTS(600,60),CHAN(60),COUNT,IP,TIME(600),IRUN,IKNOW   AIR 0020
     1/SIG1/X(600),Y(600),ITIMEE(600)                                   AIR 0030
     2/WAIT/OUT(600,10),COMAT(60),IP1,IP2                               AIR 0040
      INTEGER CO,CO2,O2,CALO2                                           AIR 0050
      N=7                                                               AIR 0060
      WRITE(6,300)                                                      AIR 0070
10    READ(5,290) CO,CO2,O2,CALO2                                       AIR 0080
      O2A=0.0                                                           AIR 0090
      O2R1=0.0                                                          AIR 0100
      O2R2=0.0                                                          AIR 0110
      CO2A=0.03744                                                      AIR 0120
      CO2R1=133.2                                                       AIR 0130
      CO2R2=-404.0                                                      AIR 0140
      CO2R3=25407.0                                                     AIR 0150
      COA=0.07061                                                       AIR 0160
      COR1=-32.142                                                      AIR 0170
      COR2=11747.0                                                      AIR 0180
      COR3=-227940.0                                                    AIR 0190
      COR4=1644900.0                                                    AIR 0200
      WRITE(7,280) CO,O2,CO2,IRUN,IKNOW                                 AIR 0210
      DO 20 KK=2,10                                                     AIR 0220
      DO 20 JJ = 1, 600                                                 AIR 0230
20    OUT(JJ,KK) = 0.                                                   AIR 0240
      IKNOW = IKNOW + 1                                                 AIR 0250
      O2R1 = 0.                                                         AIR 0260
      O2A = 0.                                                          AIR 0270
      IF (CO)150,30,30                                                  AIR 0280
30    CO = CO - JCHLO + 1                                               AIR 0290
      CO2 = CO2 - JCHLO + 1                                             AIR 0300
      O2 = O2 - JCHLO + 1                                               AIR 0310
      CALO2 = CALO2 - JCHLO + 1                                         AIR 0320
      KOUM1 = ISTAR2 - 1                                                AIR 0330
      DO 40 JJ = ISTART, KOUM1                                          AIR 0340
40    O2A = O2A + VOLTS(JJ,CALO2)                                       AIR 0350
      DIV = KOUM1 - ISTART + 1                                          AIR 0360
      O2A = O2A/DIV                                                     AIR 0370
      KOUM1=ISTAR3-1                                                    AIR 0380
      DO 50 JJ = ISTAR2, KOUM1                                          AIR 0390
50    O2R1 = O2R1 + VOLTS(JJ,CALO2)                                     AIR 0400
      DIV1 = KOUM1 - ISTAR2 + 1                                         AIR 0410
      O2R1 = O2R1/DIV1                                                  AIR 0420
      O2R1 = 21./(O2R1 - O2A)                                           AIR 0430
      O2A = - O2A * O2R1                                                AIR 0440
      IF(N)70,60,70                                                     AIR 0450
60    WRITE(6,260)                                                      AIR 0460
      WRITE(6,270) O2A,O2R1                                             AIR 0470
      WRITE(6,250)                                                      AIR 0480
      WRITE(6,240) CO2A,CO2R1,CO2R2,CO2R3                               AIR 0490
      WRITE(6,230)                                                      AIR 0500
      WRITE(6,220) COA,COR1,COR2,COR3,COR4                              AIR 0510
70    JJ3= 0                                                            AIR 0520
      DO 80 JJ = KSIG, IP                                               AIR 0530
      IF(VOLTS(JJ,CO2)-0.00001) 80,80,75                                AIR 0540
75    JJ3 = JJ3 + 1                                                     AIR 0550
      OUT(JJ3,5) = OUT(JJ, 1)                                           AIR 0560
      V=VOLTS(JJ,CO)                                                    AIR 0570
      OUT(JJ3,2)=COA+COR1*V+COR2*V*V+COR3*V*V*V+COR4*V*V*V*V            AIR 0580
      V=VOLTS(JJ,CO2)                                                   AIR 0590
      OUT(JJ3,3)=CO2A+CO2R1*V+CO2R2*V*V+CO2R3*V*V*V                     AIR 0600
      OUT(JJ3,4) = O2A + (O2R1 + O2R2*VOLTS(JJ,O2))*VOLTS(JJ,O2)        AIR 0610
80    CONTINUE                                                          AIR 0620
      WRITE(7,280) JJ3,JJ3,JJ3,IRUN,IKNOW                               AIR 0630
      IKNOW = IKNOW + 1                                                 AIR 0640
      DO 90 JJ = 2, 4                                                   AIR 0650
      DO 90 KK = 1, JJJ, 12                                             AIR 0660
      KHIGH = KK + 11                                                   AIR 0670
      WRITE(7,200)  (OUT(II,JJ),II=KK,KHIGH),IRUN,IKNTW                 AIR 0680
90    IKNTW = IKNTW + 1                                                 AIR 0690
      DO 100 JJ = 1, JJJ, 12                                            AIR 0700
      JHIGH = JJ + 11                                                   AIR 0710
      WRITE(7,210) (OUT(KK,5),KK=JJ,JHIGH),IRUN,IKNTW                   AIR 0720
100   IKNTW = IKNTW + 1                                                 AIR 0730
      N=N+1                                                             AIR 0740
      GO TO(110,120,130),N                                              AIR 0750
110   WRITE(6,190)                                                      AIR 0760
      GO TO 140                                                         AIR 0770
120   WRITE(6,180)                                                      AIR 0780
      GO TO 140                                                         AIR 0790
130   WRITE(6,170)                                                      AIR 0800
140   WRITE(6,160) (OUT(KK,5),(OUT(KK,JJ),JJ = 2, 4),KK = 1,JJJ)        AIR 0810
      GO TO 10                                                          AIR 0820
150   RETURN                                                            AIR 0830
160    FORMAT(1X,9F14.6)                                                AIR 0840
170    FORMAT('1',16X,'TABLE OF FUEL BED COMPOSITIONS, FROM POSITION 2, 1AIR 0850
     IN PERCENT, TIME IN SECONDS'                                       AIR 0860
     2///21'      TIME'        ,12X,'CO',12X,'CO2',11X,'O2',6X)         AIR 0870
180    FORMAT('1',16X,'TABLE OF FUEL BED COMPOSITIONS, FROM POSITION 1, 1AIR 0880
     IN PERCENT, TIME IN SECONDS'                                       AIR 0890
     2///21'      TIME'        ,12X,'CO',12X,'CO2',11X,'O2',6X)         AIR 0900
190    FORMAT('1',27X,'TABLE OF STACK GAS COMPOSITIONS IN PERCENT, TIME 1AIR 0910
     IN SECONDS'                                                        AIR 0920
     2///21'      TIME'        ,12X,'CO',12X,'CO2',11X,'O2',6X)         AIR 0930
200    FORMAT(12F6.3,I3,I5)                                             AIR 0940
210    FORMAT(12F6.1,I3,I5)                                             AIR 0950
220    FORMAT(20X,'VOL.PERCENT CO = ',F8.6,F6.3,'V +',F8.1,'V*V',F9.1,'V*AIR 0960
     1V*V +',F10.1,'V*V*V*V',//)                                        AIR 0970
230    FORMAT(20X,'CARBON MONOXIDE METER CALIBRATION',//)               AIR 0980
240    FORMAT(20X,'VOL. PERCENT CO2 = ',F7.5,'+',F6.2,'V',F6.1,'V*V +', AIR 0990
     1F7.1,'V*V*V',//)                                                  AIR 1000
250    FORMAT(20X,'CARBON DIOXIDE METER CALIBRATION',//)                AIR 1010
260    FORMAT(20X,'OXYGEN METER CALIBRATION',/)                         AIR 1020
270    FORMAT(20X,'VOL. PERCENT O2 = ',F6.4,' +',F9.4,'V',//)           AIR 1030
280    FORMAT(3I5,57X,I3,I5)                                            AIR 1040
290    FORMAT(4I5)                                                      AIR 1050
300    FORMAT('1',///,50X,'GAS COMPOSITIONS',///)                       AIR 1060
       END                                                              AIR 1070
```

```
      SUBROUTINE TCHRA(EMF,REF,TEMPC)                                   TCHA0010
      COMMON/TCTB/TCA(62)                                               TCHA0020
      EMF=EMF+REF                                                       TCHA0030
      XEMF = EMF                                                        TCHA0040
      IF (EMF)10,20,20                                                  TCHA0050
10    IEMF=EMF                                                          TCHA0060
      GO TO 30                                                          TCHA0070
20    IEMF=EMF+1.0000                                                   TCHA0080
      EMF= EMF+ 1.0000                                                  TCHA0090
30    IEMF = IEMF + 5                                                   TCHA0100
      EMF= EMF+ 5.0000                                                  TCHA0110
      IF (IEMF)50,40,40                                                 TCHA0120
40    IF (IEMF - 60)60,60,50                                            TCHA0130
50    TEMPC=-500.                                                       TCHA0140
      GO TO 70                                                          TCHA0150
60    CONTINUE                                                          TCHA0160
      TLOW=TCA(IEMF)                                                    TCHA0170
      THIGH=TCA(IEMF+1)                                                 TCHA0180
      CALL INTER(TLOW, THIGH, IEMF, EMF, TEMPC)                         TCHA0190
70    EMF=XEMF                                                          TCHA0200
      RETURN                                                            TCHA0210
      END                                                               TCHA0220
```

```
      SUBROUTINE INTER(ALOW,AHIGH,IVOLT,VOLT,CTEMP)                     INTR0010
      FVOLT= IVOLT                                                      INTR0020
      JVOLT = IVOLT + 1                                                 INTR0030
      GVOLT = JVOLT                                                     INTR0040
      IF (VOLT-FVOLT)20,10,10                                           INTR0050
10    CTEMP = (VOLT-FVOLT)*(AHIGH-ALOW)+ALOW                            INTR0060
      GO TO 30                                                          INTR0070
20    CTEMP = (VOLT-FVOLT)*(AHIGH-ALOW)+AHIGH                           INTR0080
30    RETURN                                                            INTR0090
      END                                                               INTR0100
```

```
      SUBROUTINE FIXIT(VOLTS)                                           FIXT0010
      DUMMY= VOLTS                                                      FIXT0020
      DUMMY=DUMMY-10.000000                                             FIXT0030
      IF(DUMMY)20,20,10                                                 FIXT0040
10    VOLTS=-(VOLTS-10.000000)                                          FIXT0050
20    DUMMY=ABS(VOLTS)                                                  FIXT0060
      IDUMM=DUMMY                                                       FIXT0070
      DUMMY=IDUMM                                                       FIXT0080
      IF(VOLTS)30,40,40                                                 FIXT0090
30    VOLTS=VOLTS+DUMMY                                                 FIXT0100
      GO TO 50                                                          FIXT0110
40    VOLTS=VOLTS-DUMMY                                                 FIXT0120
50    VOLTS=VOLTS*10.0**(6-IDUMM)                                       FIXT0130
      RETURN                                                            FIXT0140
      END                                                               FIXT0150
```

# DATA REDUCTION 3

## Fortran Program Listing

```
      REAL MOW
      COMMON [illegible]
     1[illegible]
      READ(5,10) IP
   10 FORMAT(I5)
      CALL [illegible]
      CALL [illegible]
      INT = 2
      CALL RITE2V([illegible]    UNDER
     1              DATE ,NLAST)
      WRITE(6,20) NLAST
   20 FORMAT(' TITLE IS OK IF THIS NUMBER IS 70 ',I5)
      READ(5,30) RITE1, RITE2(1), RITE2(2)
   30 FORMAT(A6,I5,2A6)
      CALL RITE2V(230,1000,1023,0,INT,6,1,RITE1,NLAST)
      WRITE(6,20) NLAST
      CALL RITE2V(830,1000,1023,0,INT,8,1,RITE2,NLAST)
      WRITE(6,20) NLAST
      CALL RITE2V(277,960,1023,0,INT,26,1,26HSUMMARY OF TEST CONDITIONS
     1,NLAST)
      WRITE(6,20) NLAST
      CALL RITE2V(290,870,1023,0,INT,9,1,9HFEED DATA,NLAST)
      CALL RITE2V(151,840,1023,0,INT,37,1,37H      WEIGHT CHARGED
     1      LBS,NLAST)
      WRITE(6,20) NLAST
      READ(5,40) RITE1
   40 FORMAT(A6)
      CALL RITE2V(675,840,1023,0,INT,6,1,RITE1,NLAST)
      WRITE(6,20) NLAST
      CALL RITE2V(290,810,1023,0,INT,30,1,30HBULK DENSITY OF FUEL  *
     1 LBS/CU. FT.,NLAST  )
      WRITE(6,20) NLAST
      CALL RITE2V(290,780,1023,0,INT,29,1,29HPERCENT MOISTURE      *
     1   ,NLAST)
      WRITE(6,20) NLAST
      READ(5,40) RITE1
      CALL RITE2V(675,810,1023,0,INT,6,1,RITE1,NLAST)
      CALL RITE2V(290,750,1023,0,INT,29,1,29HPERCENT WOOD          *
     1  ,NLAST)
      WRITE(6,20) NLAST
      READ(5,40) RITE1
      CALL RITE2V(675,780,1023,0,INT,6,1,RITE1,NLAST)
      WRITE(6,20) NLAST
      CALL RITE2V(290,720,1023,0,INT,29,1,29HPERCENT PAPER         *
     1  ,NLAST)
      WRITE(6,20) NLAST
      READ(5,40) RITE1
      CALL RITE2V(675,750,1023,0,INT,6,1,RITE1,NLAST)
      WRITE(6,20) NLAST
      CALL RITE2V(290,690,1023,0,INT,29,1,29HPERCENT INERT         *
     1  ,NLAST)
      WRITE(6,20) NLAST
      READ(5,40) RITE1
      CALL RITE2V(675,720,1023,0,INT,6,1,RITE1,NLAST)
      WRITE(6,20) NLAST
      CALL RITE2V(290,660,1023,0,INT,29,1,29HPERCENT CARDBOARD     *
     1  ,NLAST)
      WRITE(6,20) NLAST
      READ(5,40) RITE1
      CALL RITE2V(675,690,1023,0,INT,6,1,RITE1,NLAST)
      WRITE(6,20) NLAST
      READ(5,40) RITE1
      CALL RITE2V(675,660,1023,0,INT,6,1,RITE1,NLAST)
      CALL RITE2V(880,940,1023,0,INT,4,1,4HSCFM,NLAST)
      CALL RITE2V(880,910,1023,0,INT,4,1,4HSCFM,NLAST)
      CALL RITE2V(880,880,1023,0,INT,4,1,4HSCFM,NLAST)
      CALL RITE2V(880,650,1023,0,INT,4,1,4HSCFM,NLAST)
      CALL RITE2V(286,600,1023,0,INT,13,1,13HAIR FLOW DATA,NLAST)
      WRITE(6,20) NLAST
      CALL RITE2V(70,570,1023,0,INT,49,1,49H          OVERFIRE AIR NOZ
     1ZLE               SCFM,NLAST)
      WRITE(6,20) NLAST
      READ(5,50)  (RITE2(JJ),JJ=1,3)
      CALL RITE2V(640,570,1023,0,INT,12,1,RITE2,NLAST)
      WRITE(6,20) NLAST
      READ(5,50)  (RITE2(JJ),JJ=1,3)
      CALL RITE2V(640,540,1023,0,INT,12,1,RITE2,NLAST)
      WRITE(6,20) NLAST
      READ(5,50)  (RITE2(JJ),JJ=1,3)
      CALL RITE2V(640,510,1023,0,INT,12,1,RITE2,NLAST)
      WRITE(6,20) NLAST
      READ(5,50)  (RITE2(JJ),JJ=1,3)
      CALL RITE2V(640,480,1023,0,INT,12,1,RITE2,NLAST)
      WRITE(6,20) NLAST
      READ(5,50)  (RITE2(JJ),JJ=1,3)
   50 FORMAT(3A6)
      CALL RITE2V(640,450,1023,0,INT,12,1,RITE2,NLAST)
      WRITE(6,20) NLAST
      READ(5,60) RITE2(1), RITE2(2), MOW
      FORMAT(2A6, E10.0)
   60 FORMAT(A6,I5,A6,F20.10)
      IF(MOW)80,70,70
   70 CALL RITE2V(286,390,1023,0,INT,20,1,20HUNDERFIRE AIR NOZZLE
     1 ,NLAST)
      CALL RITE2V(712,390,1023,0,INT,8,1,RITE2,NLAST)
      CALL RITE2V(880,390,1023,0,INT,4,1,4HSCFM,NLAST)
      GO TO 90
   80 CALL RITE2V(286,390,1023,0,INT,15,1,15HNATURAL DRAUGHT,NLAST)
   90 READ (5,100) IDUMY
  100 FORMAT(I1/)
      READ(5,110) KSIG, LMI
  110 FORMAT(2I5)
      IP = IP + 1 - KSIG
      IPSTOR=IP
      WRITE(6,120) IP
  120 FORMAT(//,' THE NUMBER OF DATA POINTS IS ',I5)
      READ (5,130) (TIME(JJ), JJ = 1, IP)
  130 FORMAT(12F6.1)
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      IMIDT=0                                                           MAIN1090
      ITIMEA=150                                                        MAIN1100
      ITIME1=200                                                        MAIN1110
      IF(TIME(IP).LT.200) GO TO 160                                     MAIN1120
      DO 140 JJ=1,25                                                    MAIN1130
      ITIMEA=ITIMEA+400                                                 MAIN1140
      ITIME1=ITIME1+400                                                 MAIN1150
      IF(TIME(IP).GE.ITIMEA.AND.TIME(IP).LE.ITIME1) GO TO 150           MAIN1160
140   IMIDT=IMIDT+2                                                     MAIN1170
150   AMIDT=IMIDT*100                                                   MAIN1180
      ENDT=IMIDT*200                                                    MAIN1190
      GO TO 170                                                         MAIN1200
160   AMIDT=100.0                                                       MAIN1210
      ENDT=200.0                                                        MAIN1220
170   WRITE(6,180) AMIDT,ENDT                                           MAIN1230
180   FORMAT(' AMIDT, ENDT                      ',2F15.6)               MAIN1240
      WRITE(6,190)                                                      MAIN1250
190   FORMAT(//,'           TEMPERATURE PLOTS',//)                      MAIN1260
200   READ(5,210) IFOK                                                  MAIN1270
210   FORMAT(I2)                                                        MAIN1280
      WRITE(6,220) IFOK,KSIG,LMI                                        MAIN1290
220   FORMAT(' IFOK, KSIG, LMI ',3I2)                                   MAIN1300
      TMAX=2400.0                                                       MAIN1310
      IP=IPSTOR                                                         MAIN1320
      IF(IFOK)440,440,230                                               MAIN1330
230   DO 260 KK = 1, LMI                                                MAIN1340
      READ(5,130) (OUT(JJ,KK),JJ = 1, IP)                               MAIN1350
      IJ=0                                                              MAIN1360
      DO 250 JJ=1,IP                                                    MAIN1370
      IF(OUT(JJ,KK))250,250,240                                         MAIN1380
240   IJ=IJ+1                                                           MAIN1390
      MOUT(IJ,KK)=OUT(JJ,KK)                                            MAIN1400
      DTIME(IJ,KK)=TIME(JJ)                                             MAIN1410
250   CONTINUE                                                          MAIN1420
      DIP(KK)=IJ                                                        MAIN1430
260   CONTINUE                                                          MAIN1440
      DO 290 KK=1,LMI                                                   MAIN1450
      IP=DIP(KK)                                                        MAIN1460
      DO 270 JJ=1,IP                                                    MAIN1470
      IF(AMIDT-DTIME(JJ,KK))280,280,270                                 MAIN1480
270   CONTINUE                                                          MAIN1490
280   DIP1(KK)=JJ-1                                                     MAIN1500
      DIP2(KK)=DIP(KK)-JJ+1                                             MAIN1510
290   CONTINUE                                                          MAIN1520
      CALL DXDYV(2.0,,TMAX,DYSTR,MSTR,JSTR,NYSTR,10.0,IERR2)            MAIN1530
      CALL DXDYV(1.0,,AMIDT,DXSTR,NSTR,ISTR,NXSTR,10.0,IERR)            MAIN1540
      ISTR = - ISTR                                                     MAIN1550
      JSTR = - JSTR                                                     MAIN1560
      WRITE(6,300) DXSTR,NSTR,ISTR,NXSTR,IERR                           MAIN1570
      WRITE(6,310) DYSTR,MSTR,JSTR,NYSTR,IERR2                          MAIN1580
300   FORMAT(' DXSTR,NSTR,ISTR,NXSTR,XGRID ERROR,',E15.6,4I8)           MAIN1590
310   FORMAT(' DYSTR,MSTR,JSTR,NYSTR,YGRID ERROR,',E15.6,4I8)           MAIN1600
      IF(IERR.EQ.1.OR.IERR2.EQ.1) GO TO 320                             MAIN1610
      GO TO 340                                                         MAIN1620
320   WRITE(6,330)                                                      MAIN1630
330   FORMAT(' GRID SPECIFIED IS IMPOSSIBLE')                           MAIN1640
340   CALL SETMIV(24,0,24,24)                                           MAIN1650
      CALL GRIDIV(3     ,0.,AMIDT,0.0   ,TMAX ,DXSTR,DYSTR,NSTR,MSTR,ISTR,MAIN1660
     1 JSTR,NXSTR,NYSTR)                                                MAIN1670
      CALL RIGV                                                         MAIN1680
      READ(5,350) (COMNT(JJ),JJ=1,60)                                   MAIN1690
350   FORMAT(20A4/20A4/20A4)                                            MAIN1700
      CALL RITE2V(92,  965,  972,  0,  5,  240,  1,COMNT,NLAST)         MAIN1710
      CALL RITE2V(10, 323,1023,90,3,21,1,'TEMPERATURE IN DEG. F',NLAST2)MAIN1720
      CALL RITE2V(400,0,1023,0,3,15,1,'TIME IN SECONDS',NLAST3)         MAIN1730
      WRITE(6,360) NLAST3,NLAST2,NLAST                                  MAIN1740
360   FORMAT(' NLAST3,2,1',3I6)                                         MAIN1750
      DO 380 KK = 1, LMI                                                MAIN1760
      IP1=DIP1(KK)                                                      MAIN1770
      DO 370 JJ = 1, IP1                                                MAIN1780
      X(JJ)=DTIME(JJ,KK)                                                MAIN1790
370   Y(JJ)=MOUT(JJ,KK)                                                 MAIN1800
      CALL GRAF1V(X,Y,IERR,IP1,1)                                       MAIN1810
      CALL APLOTV(IP1,X,Y,1,1,1,KK,IERR3)                               MAIN1820
380   WRITE(6,390) KK,IERR,IERR3                                        MAIN1830
390   FORMAT(' PLOT NO.,LINE ERRORS,PLOT ERRORS',3I6)                   MAIN1840
      CALL SETMIV( 0,24,24,24)                                          MAIN1850
      JSTR=0                                                            MAIN1860
      CALL GRIDIV(3     ,AMIDT,ENDT,0.0     ,TMAX ,DXSTR,DYSTR,NSTR,MSTR MAIN1870
     1,ISTR,JSTR,NXSTR,NYSTR)                                           MAIN1880
      CALL RIGV                                                         MAIN1890
      CALL RITE2V(400,0,1023,0,3,15,1,'TIME IN SECONDS',NLAST3)         MAIN1900
      DO 410 KK = 1, LMI                                                MAIN1910
      IP2=DIP2(KK)                                                      MAIN1920
      DO 400 JJ = 1, IP2                                                MAIN1930
      K3=JJ+DIP1(KK)                                                    MAIN1940
      X(JJ)=DTIME(K3,KK)                                                MAIN1950
400   Y(JJ)=MOUT(K3,KK)                                                 MAIN1960
      CALL APLOTV(IP2,X ,Y ,1,1,1,KK,IERR3)                             MAIN1970
      CALL GRAF1V(X ,Y ,IERR,IP2,1)                                     MAIN1980
410   WRITE(6,390) KK,IERR,IERR3                                        MAIN1990
      READ(5,420) IDUMY                                                 MAIN2000
420   FORMAT(I5)                                                        MAIN2010
      IF(IDUMY)440,430,430                                              MAIN2020
430   READ(5,110 ) KSIG, LMI                                            MAIN2030
                                                                        MAIN2040
      GO TO 200                                                         MAIN2050
440   CALL WEIGHT(AMIDT,ENDT,IPSTOR)                                    MAIN2060
      CALL AIR(AMIDT,ENDT)                                              MAIN2070
      CALL WAVE                                                         MAIN2080
      CALL PLTND(NN)                                                    MAIN2090
      WRITE(6,450) NN                                                   MAIN2100
450   FORMAT(//,' NUMBER OF FRAMES IS = ',I9)                           MAIN2110
      STOP                                                              MAIN2120
      END                                                               AIR 0010
      SUBROUTINE AIR(TIME1,TIME2)                                       AIR 0020
      REAL MOUT                                                         AIR 0030
      COMMON     TIME(600),Y(600),X(600),OUT(600,9),MOUT(600,9),        AIR 0040
     1COMNT(60),DIP1(9),DIP2(9),DIP(9),DTIME(600,9),RITE2(3)
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      WRITE(6,10)                                                       AIR 0050
10    FORMAT(//,'          GAS COMPOSITION PLOTS',//)                   AIR 0060
      ICOUNT=1                                                          AIR 0070
20    READ(5,30) JCHO2,JCHCO2,JCHCO                                     AIR 0080
30    FORMAT(3I5)                                                       AIR 0090
      WRITE(6,40) JCHO2,JCHCO2,JCHCO                                    AIR 0100
40    FORMAT(3I5)                                                       AIR 0110
      READ(5,50) IP                                                     AIR 0120
      AMAX = 0.                                                         AIR 0130
50    FORMAT(I5)                                                        AIR 0140
      IF(IP)330,330,60                                                  AIR 0150
60    DO 70 KK = 1, 3                                                   AIR 0160
70    READ(5,80) (OUT(JJ,KK),JJ=1,IP)                                   AIR 0170
80    FORMAT(12F6.3)                                                    AIR 0180
      READ(5,90) (TIME(JJ),JJ=1,IP)                                     AIR 0190
90    FORMAT(12F6.1)                                                    AIR 0200
      DO 110 KK=1,3                                                     AIR 0210
      DO 110 JJ=1,IP                                                    AIR 0220
      IF(OUT(JJ,KK)-AMAX)110,110,100                                    AIR 0230
100   AMAX=OUT(JJ,KK)                                                   AIR 0240
110   CONTINUE                                                          AIR 0250
      IF(AMAX.LE.22.0) GO TO 48                                         AIR 0260
      IAMAX=AMAX                                                        AIR 0270
      IAMAX1=(IAMAX/2)*2                                                AIR 0280
      IFIX=IAMAX1-IAMAX                                                 AIR 0290
      IF(IFIX.GE.0) GO TO 120                                           AIR 0300
      IAMAX=IAMAX+1                                                     AIR 0310
120   AMAX=IAMAX                                                        AIR 0320
      GO TO 130                                                         AIR 0330
      AMAX=22.0                                                         AIR 0340
130   DO 150 KK=1,3                                                     AIR 0350
      IJ=0                                                              AIR 0360
      DO 140 JJ=1,IP                                                    AIR 0370
      IF(OUT(JJ,KK).EQ.-5.0) GO TO 44                                   AIR 0380
      IJ=IJ+1                                                           AIR 0390
      MOUT(IJ,KK)=OUT(JJ,KK)                                            AIR 0400
      DTIME(IJ,KK)=TIME(JJ)                                             AIR 0410
140   CONTINUE                                                          AIR 0420
      DIP(KK)=IJ                                                        AIR 0430
150   CONTINUE                                                          AIR 0440
      DO 160 KK=1,3                                                     AIR 0450
      IP=DIP(KK)                                                        AIR 0460
      DO 160 JJ=1,IP                                                    AIR 0470
      IF(MOUT(JJ,KK).GT.0.0) GO TO 26                                   AIR 0480
      MOUT(JJ,KK)=0.0                                                   AIR 0490
160   CONTINUE                                                          AIR 0500
      DO 190 KK=1,3                                                     AIR 0510
      IP=DIP(KK)                                                        AIR 0520
      DO 170 JJ=1,IP                                                    AIR 0530
      IF(TIME1-DTIME(JJ,KK))180,180,170                                 AIR 0540
170   CONTINUE                                                          AIR 0550
180   DIP1(KK)=JJ-1                                                     AIR 0560
      DIP2(KK)=DIP(KK)-JJ+1                                             AIR 0570
190   CONTINUE                                                          AIR 0580
      CALL DXDYV(1,0.,TIME1,DXSTR,NSTR,ISTR,NXSTR,10,0,IERR)            AIR 0590
      CALL DXDYV(2,0.0,AMAX,DYSTR,MSTR,JSTR,NYSTR,10,0,IERR2)           AIR 0600
      ISTR = -ISTR                                                      AIR 0610
      JSTR = - JSTR                                                     AIR 0620
      WRITE(6,240) DXSTR,NSTR,ISTR,NXSTR,IERR                           AIR 0630
      WRITE(6,250) DYSTR,MSTR,JSTR,NYSTR,IERR2                          AIR 0640
      CALL SETMIV(24,0,24,24)                                           AIR 0650
      CALL GRIDIV(3,0.0,TIME1,0.0,AMAX,DXSTR,DYSTR,NSTR,MSTR,ISTR,      AIR 0660
     1JSTR,NXSTR,NYSTR)                                                 AIR 0670
      CALL BIGV                                                         AIR 0680
      READ(5,200) (COMNT(JJ),JJ = 1, 60)                                AIR 0690
200   FORMAT(20A4/20A4/20A4)                                            AIR 0700
      CALL RITE2V(400,0,1023,0,3,15,1,'TIME IN SECONDS',NLAST3)         AIR 0710
      CALL RITE2V(92,965,972,0,5,240,1,COMNT,NLAST)                     AIR 0720
      CALL RITE2V(10,250,1023,90,3,29,1,'COMPOSITION VOL   - DRY BASIS',AIR 0730
     1                 NLAST2)                                          AIR 0740
      WRITE(6,210) NLAST3,NLAST2,NLAST                                  AIR 0750
210   FORMAT(' NLAST3,2,1 FOR AIR',3I6)                                 AIR 0760
      DO 230 KK = 1, 3                                                  AIR 0770
      IP1=DIP1(KK)                                                      AIR 0780
      DO 220 JJ=1,IP1                                                   AIR 0790
      X(JJ)=DTIME(JJ,KK)                                                AIR 0800
220   Y(JJ)=MOUT(JJ,KK)                                                 AIR 0810
      CALL GRAF1V(X,Y,IERR,IP1,1)                                       AIR 0820
      CALL APLOTV( IP1,X,Y,1,1,1,KK,IERR3)                              AIR 0830
230   WRITE(6,260) ICOUNT,IERR,IERR3                                    AIR 0840
240   FORMAT(' DXSTR,NSTR,ISTR,NXSTR,XGRID ERROR,',E15.6,4I8)           AIR 0850
250   FORMAT(' DYSTR,MSTR,JSTR,NYSTR,YGRID ERROR,',E15.6,4I8)           AIR 0860
260   FORMAT(' GAS PLOT NO.,LINE ERRORS,PLOT ERRORS',3I6)               AIR 0870
      CALL SETMIV( 0,24,24,24)                                          AIR 0880
      JSTR=0                                                            AIR 0890
      CALL GRIDIV(3,TIME1,TIME2,0.0,AMAX,DXSTR,DYSTR,NSTR,MSTR,         AIR 0900
     1ISTR,JSTR,NXSTR,NYSTR)                                            AIR 0910
      CALL BIGV                                                         AIR 0920
      CALL RITE2V(400,0,1023,0,3,15,1,'TIME IN SECONDS',NLAST3)         AIR 0930
      DO 280 KK=1,3                                                     AIR 0940
      IP2=DIP2(KK)                                                      AIR 0950
      DO 270 JJ=1,IP2                                                   AIR 0960
      K3=JJ+DIP1(KK)                                                    AIR 0970
      X(JJ)=DTIME(K3,KK)                                                AIR 0980
270   Y(JJ)=MOUT(K3,KK)                                                 AIR 0990
      CALL APLOTV( IP2,X,Y,1,1,1,KK,IERR3)                              AIR 1000
      CALL GRAF1V(X,Y,IERR,IP2,1)                                       AIR 1010
280   WRITE(6,260) ICOUNT,IERR,IERR3                                    AIR 1020
      ICOUNT = ICOUNT + 1                                               AIR 1030
      IF(ICOUNT - 3)20,20,290                                           AIR 1040
290   ICOUNT=ICOUNT-1                                                   AIR 1050
      WRITE(6,300) ICOUNT                                               AIR 1060
300   FORMAT(' ICOUNT WAS',I6)                                          AIR 1070
      READ(5,50) IP                                                     AIR 1080
      IF(IP+1)310,330,310                                               AIR 1090
310   WRITE(6,320)                                                      AIR 1100
320   FORMAT(//,'  ERROR IN DATA SET ',/)                               AIR 1110
330   RETURN                                                            AIR 1120
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                                                                        AIR 1130
      END                                                               WEIT0010
      SUBROUTINE WEIGHT(TIME1,TIME2)                                    WEIT0020
      REAL MOUT                                                         WEIT0030
      COMMON    TIME(600),Y(600),X(600),OUT(600,9),MOUT(600,9),         WEIT0040
     1COMNT(60),DIP1(9),DIP2(9),DEPTH(27),DTIME(600,9),RITE2(3)         WEIT0050
      INTEGER Y                                                         WEIT0060
      WRITE(6,10)                                                       WEIT0070
10    FORMAT(//,'          WEIGHT PLOT',//)                             WEIT0080
      IP=NP                                                             WEIT0090
      AMAX = 0.                                                         WEIT0100
      READ(5,20) NV                                                     WEIT0110
20    FORMAT(I5)                                                        WEIT0120
      IF(NV)200,30,30                                                   WEIT0130
30    READ(5,40) (OUT(JJ, 1), JJ = 1, IP)                               WEIT0140
40    FORMAT(12F4.2)                                                    WEIT0150
      IJ=0                                                              WEIT0160
      DO 50 JJ=1,IP                                                     WEIT0170
      IF(OUT(JJ,1).EQ.-5.0.OR.OUT(JJ,1).EQ.0.0) GO TO 50                WEIT0180
      IJ=IJ+1                                                           WEIT0190
      MOUT(IJ,1)=OUT(JJ,1)                                              WEIT0200
      DTIME(IJ,1)=TIME(JJ)                                              WEIT0210
50    CONTINUE                                                          WEIT0220
      IP=IJ                                                             WEIT0230
      DO 60 JJ=1,IP                                                     WEIT0240
60    OUT(JJ,1)=MOUT(JJ,1)                                              WEIT0250
      DO 80 JJ = 1, IP                                                  WEIT0260
      IF(AMAX - OUT(JJ, 1))70,80,80                                     WEIT0270
70    AMAX = OUT(JJ, 1)                                                 WEIT0280
80    CONTINUE                                                          WEIT0290
      IAMAX=AMAX                                                        WEIT0300
90    IAMAX1=(IAMAX/5)*5                                                WEIT0310
      IFIX=IAMAX1-IAMAX                                                 WEIT0320
      IF(IFIX.GE.0) GO TO 100                                           WEIT0330
      IAMAX=IAMAX+1                                                     WEIT0340
      GO TO 90                                                          WEIT0350
100   AMAX=IAMAX                                                        WEIT0360
      DO 110 KK=1,IP                                                    WEIT0370
      IF(TIME1-DTIME(KK,1))120,120,110                                  WEIT0380
110   CONTINUE                                                          WEIT0390
120   IP1=KK-1                                                          WEIT0400
      IP2= IP-KK+1                                                      WEIT0410
      DO 130 JJ=3,IP1                                                   WEIT0420
      Y(JJ)=(OUT(JJ,1)+OUT(JJ+1,1)+OUT(JJ-1,1)+OUT(JJ-2,1))/4.0         WEIT0430
      IF(Y(JJ).GT.0.0) GO TO 8                                          WEIT0440
      Y(JJ)=0.0                                                         WEIT0450
      X(JJ)=DTIME(JJ,1)                                                 WEIT0460
130   CONTINUE                                                          WEIT0470
      Y(1)=(3.0*OUT(1,1)+OUT(2,1))/4.0                                  WEIT0480
      IF(Y(1).GT.0.0) GO TO 9                                           WEIT0490
      Y(1)=0.0                                                          WEIT0500
      X(1)=DTIME(1,1)                                                   WEIT0510
      Y(2)=(2*OUT(1,1)+OUT(2,1)+OUT(3,1))/4.0                           WEIT0520
      IF(Y(2).GT.0.0) GO TO 15                                          WEIT0530
      Y(2)=0.0                                                          WEIT0540
      X(2)=DTIME(2,1)                                                   WEIT0550
      CALL DXDYV(2,0.0,AMAX,DYSTR,MSTR,JSTR,NYSTR,8.,IERR2)             WEIT0560
      CALL DXDYV(1,0.,TIME1,DXSTR,NSTR,ISTR,NXSTR,8.,IERR)              WEIT0570
      ISTR = -ISTR                                                      WEIT0580
      JSTR = - JSTR                                                     WEIT0590
      WRITE(6,180) DXSTR,NSTR,ISTR,NXSTR,IERR                           WEIT0600
      WRITE(6,190) DYSTR,MSTR,JSTR,NYSTR,IERR2                          WEIT0610
      CALL SETMIV(24,0,24,24)                                           WEIT0620
      CALL GRID1V(3,0.,TIME1,0.,AMAX,DXSTR,DYSTR,NSTR,MSTR,ISTR,JSTR,   WEIT0630
     1NXSTR,NYSTR)                                                      WEIT0640
      CALL BIGV                                                         WEIT0650
      READ(5,140) (COMNT(JJ) ,JJ=1,60)                                  WEIT0660
140   FORMAT(20A4/20A4/20A4)                                            WEIT0670
      CALL RITE2V(400,0,1023,0,3,15,1,'TIME IN SECONDS',NLAST3)         WEIT0680
      CALL RITE2V(92,965,972,0,5,240,1,COMNT,NLAST)                     WEIT0690
      CALL RITE2V(10,343,1023,90,3,19,1,'WEIGHT LOSS IN LBS.',NLAST2)   WEIT0700
      WRITE(6,150) NLAST3,NLAST2,NLAST                                  WEIT0710
150   FORMAT(' NLAST3,2,1',3I6)                                         WEIT0720
      CALL GRAF1V(X,Y,IERR,IP1,1)                                       WEIT0730
      CALL APLOTV(IP1,X,Y,1,1,1,1,IERR3)                                WEIT0740
      WRITE(6,160) IERR,IERR3                                           WEIT0750
160   FORMAT(' WEIGHT PLOT,LINE ERRORS,PLOT ERRORS',2I6)                WEIT0760
      DO 170 KK = 1, IP2                                                WEIT0770
      K3 = KK + IP1                                                     WEIT0780
      X(KK)=DTIME(K3,1)                                                 WEIT0790
170   Y(KK) = OUT(K3,1)                                                 WEIT0800
      CALL SETMIV( 0,24,24,24)                                          WEIT0810
      JSTR=0                                                            WEIT0820
180   FORMAT(' DXSTR,NSTR,ISTR,NXSTR,XGRID ERROR,',E15.6,4I8)           WEIT0830
190   FORMAT(' DYSTR,MSTR,JSTR,NYSTR,YGRID ERROR,',E15.6,4I8)           WEIT0840
      CALL GRID1V(3,TIME1,TIME2,0.,AMAX,DXSTR,DYSTR,NSTR,MSTR,ISTR,     WEIT0850
     1,ISTR,NXSTR,NYSTR)                                                WEIT0860
      CALL BIGV                                                         WEIT0870
      CALL RITE2V(400,0,1023,0,3,15,1,'TIME IN SECONDS',NLAST3)         WEIT0880
      CALL APLOTV(IP2,X,Y,1,1,1,1,IERR3)                                WEIT0890
      CALL GRAF1V(X,Y,IERR,IP2,1)                                       WEIT0900
      WRITE(6,160) IERR,IERR3                                           WEIT0910
200   RETURN                                                            WEIT0920
      END                                                               WAVE0010
      SUBROUTINE WAVE                                                   WAVE0020
      REAL MOUT                                                         WAVE0030
      COMMON TIME(600),YY2(600),X(600),OUT(600,9),MOUT(600,9),          WAVE0040
     1COMNT(60),DEPTH(27),TYME(600,9),RITE2(3)                          WAVE0050
      DIMENSION TEST(5)                                                 WAVE0060
      TYMAX=0.0                                                         WAVE0070
      WRITE(6,10)                                                       WAVE0080
10    FORMAT(//,'          IGNITION WAVE PLOT',//)                      WAVE0090
      READ(5,20) IDUMY                                                  WAVE0100
20    FORMAT(I5)                                                        WAVE0110
      READ(5,30) (TEST(III) ,III=1,5)                                   WAVE0120
30    FORMAT(5F6.1)                                                     WAVE0130
      IF(TEST(1))170,40,40                                              WAVE0140
40    READ(5,50) ITEST, LHI                                             WAVE0150
50    FORMAT(2I5)
```

```
      READ(5,60) (DEPTH(JJ),JJ = 1, LHI)                                WAVE0160
60    FORMAT(12F6.1)                                                    WAVE0170
      DO 90 KK = 1, ITEST                                               WAVE0180
      READ(5,70) (TYME(JJ,KK),JJ=1,LHI)                                 WAVE0190
70    FORMAT(12F6.1)                                                    WAVE0200
      DO 90 JJ = 1, LHI                                                 WAVE0210
      IF(TYMAX-TYME(JJ,KK))80,90,90                                     WAVE0220
80    TYMAX=TYME(JJ,KK)                                                 WAVE0230
90    CONTINUE                                                          WAVE0240
      CALL DXDYV(1,0.,0.,TYMAX,DXSTR,NSTR,ISTR,NXSTR,10,0,IERR)         WAVE0250
      CALL DXDYV(2,0.,0.,DEPTH(LHI),DYSTR,MSTR,JSTR,NYSTR,10,0,IERR2)   WAVE0260
      WRITE(6,100) DXSTR,NSTR,ISTR,NXSTR,IERR                           WAVE0270
      WRITE(6,110) DYSTR,MSTR,JSTR,NYSTR,IERR2                          WAVE0280
100   FORMAT(' DXSTR,NSTR,ISTR,NXSTR,XGRID ERROR,',E15.6,4I8)           WAVE0290
110   FORMAT(' DYSTR,MSTR,JSTR,NYSTR,YGRID ERROR,',E15.6,4I8)           WAVE0300
      CALL SETMIV(24,0,24,24)                                           WAVE0310
      CALL GRID1V(3,0.,0.,TYMAX,0.,0.,DEPTH(LHI),DXSTR,DYSTR,NSTR,MSTR,ISTR,WAVE0320
     1JSTR,NXSTR,NYSTR)                                                 WAVE0330
      CALL RITE2V(10,377,1023, 90,4,15,1,'DEPTH IN INCHES',NLAST2)      WAVE0340
      CALL RITE2V(400,0,1023,0,4,15,1,'TIME IN SECONDS',NLAST3)         WAVE0350
      READ (5,120) (COMNT(JJ),JJ=1, 60)                                 WAVE0360
120   FORMAT(20A6/20A6/20A6)                                            WAVE0370
      CALL RITE2V(219, 119,  974,  0,  5,  240,  1,COMNT,NLAST1)        WAVE0380
      DO 150 KK = 1, ITEST                                              WAVE0390
      DO 140 JJ= 1, LHI                                                 WAVE0400
      IF(TYME(JJ,KK)) 130,140,140                                       WAVE0410
130   TYME(JJ,KK)=TYME(JJ-1,KK)+(DEPTH(JJ)-DEPTH(JJ-1))*(TYME(JJ+1,KK)- WAVE0420
     1TYME(JJ-1,KK))/(DEPTH(JJ+1)-DEPTH(JJ-1))                          WAVE0430
140   YY2(JJ) = TYME(JJ,KK)                                             WAVE0440
      CALL GRAF1V(YY2,DEPTH,IERR,LHI,1)                                 WAVE0450
      CALL APLOTV(LHI,YY2,DEPTH,1,1,1,JJ,IERR3)                         WAVE0460
150   WRITE(6,160) IERR,IERR3                                           WAVE0470
160   FORMAT(' IGNITION PLOT,LINE ERROR,PLOT ERRORS',2I6)               WAVE0480
170   RETURN                                                            WAVE0490
      END                                                               WAVE0500
```

# APPENDIX H

## Complete Data Set for Run 17

# TABLE H.I

## Instrument to Data Acquisition System Corrections for Run 17

## Table H.I.

Instrument to Data Acquisition System Connections

| Channel Number | | Instrument Location | |
|---|---|---|---|
| 140 | | Indication Channel | |
| 141 | Fuel Bed Thermocouple | 25 inches from grate (center) | |
| 142 | Fuel Bed Thermocouple | 23 inches from grate (center) | |
| 143 | Fuel Bed Thermocouple | 19 inches from grate (center) | |
| 144 | Fuel Bed Thermocouple | 18 inches from grate (center) | |
| 145 | Fuel Bed Thermocouple | 15 inches from grate (edge) | |
| 146 | Fuel Bed Thermocouple | 13 inches from grate (edge) | |
| 147 | Fuel Bed Thermocouple | 11 inches from grate (edge) | |
| 148 | Fuel Bed Thermocouple | 9 inches from grate (edge) | |
| 149 | Fuel Bed Thermocouple | 7 inches from grate (edge) | |
| 150 | Fuel Bed Thermocouple | 4 inches from grate (edge) | |
| 151 | Fuel Bed Thermocouple | 2 inches from grate (edge) | |
| 152 | Fuel Bed Thermocouple | 0 inches from grate | |
| 153 | Heat Loss Probe 1 | Thermocouple 1 (longest) | See Fig. A.1 for location and dimension |
| 154 | Heat Loss Probe 1 | Thermocouple 2 | |
| 155 | Heat Loss Probe 1 | Thermocouple 3 (shortest) | |
| 156 | Heat Loss Probe 2 | Thermocouple 4 (longest) | |
| 157 | Heat Loss Probe 2 | Thermocouple 5 | |
| 158 | Heat Loss Probe 2 | Thermocouple 6 (shortest) | |
| 159 | Heat Loss Probe 3 | Thermocouple 7 (longest) | |
| 160 | Heat Loss Probe 3 | Thermocouple 8 | |
| 161 | Heat Loss Probe 3 | Thermocouple 9 (shortest) | |
| 162 | Overfire Section Inside | Refractory Thermocouple 1 | |

## TABLE H.II

## Output Voltages for Run 17

Note: This is a listing of the card output from the program DATA REDUCTION 1. The number beginning with an eight at the start of each block of data is the time at which that block of data was recorded (i.e., 8143040 represents 14 hrs 30 mins and 40 secs). The number immediately to the right of the time is the output from the first channel recorded (140). The output from the last channel recorded (187) is printed immediately before the string of zeros on the last card in that block of data. See Table G.I for a list of channel numbers and the corresponding instrument to which they were connected. The voltages are read as follows: 4021129 represents 21129 x $10^{-4}$ volts or 2.1129 volts; 14021129 represents -2.1129 volts. The last column of numbers on the right gives the card number and the penultimate column on the right gives the run number.

```
8111750 4055838 5957766 51122·/ 6026662 6001457160058861603076616094066 17   1
6055060 6065367 6319324616002·/ 6051370160376076 6031071 6036665 6056927 17   2
6005296160686527161877216011521·1 6119630 6036775 6061238 6039036 6060000 17   3
6035178 6035260 6032095 60227·/ 6022065 6002310 6001331 6002043 6002001 17   4
6001363 6053866 6036866 30121 <1606095011600309261600701011600000316000001 17   5
16050001160000271637222716000?0.1      0       1       0       0       0 17   6
8111800 4056636 6011033 52156·0 6057802 6028026 6008696160168601608 6619 17   7
6068920 6063766 6056111 6063?·4 6033371160?2536 6015885 6020670 6059662 17   8
6025819160916001604372?1602566·/ 6022725 6036861 6061366 6039043 6059595 17   9
6035270 6035320 6032166 6022?26 6062062 6002316 6001932 6002047 6001999 17  10
6001366 6009097 6036061 30121 <16600600 6600931160001041600000316000001 17  11
1600000116030001316030206116010?·1      0       0       0       0       0 17  12
8111810 4055770 6013330 51223.· 6046641 6038610 6011295 600579616098055 17  13
6029563 6036665 6065532 6031176 6026669 6012667 6015670 6022963 6065906 17  14
6025760160961651603922216012?·/ 6022226 6036066 6061665 6019158 6059687 17  15
6035368 6035621 6032221 6026?·6 6022110 6002320 6001934 6002049 6002000 17  16
6001366160?8023 6036651 30121 <16010961916000072160000671600000216000002 17  17
1600002160003071600008216000?0 1      0       0       0       0       0 17  18
8111820 4055726 6010716 59269·/ 6056013 6039996 6013887 601666416099630 17  19
6017393 6036028 6062083 6046?·3 6025915 6019116 6019633 6018927 6065188 17  20
6028826160766111609177311602121·6 6038608 6017035 6041534 6039214 6058683 17  21
6035666 6035516 6032374 6020?·/ 6022022 6002322 6001935 6002091 6001993 17  22
6001363160043627 6036377 30121 <16030955916009096160001131600000416000002 17  23
1600000116000082161??772160?70·1      0       0       0       0       0 17  24
8111830 4055670 6015066 50292·/ 6026636 6036407 6013393 602114616097086 17  25
6005971 6037365 6037573 6063?·1 6024181 6021821 6024201 6014199 6060865 17  26
6030261160793741609342416022?·? 6062337 6037126 6061900 6039268 6059957 17  27
6035560 6018602 6032671 60256 · 6022074 6002327 6001941 6002096 6002006 17  28
6001367160?1322 6036864 30121 <16000563 60000321600004116000004160000002 17  29
16000001160300031603002?16?000·1      0       0       0       0       0 17  30
8111860 4055621 6317666 59313·/ 6350707 6026627 6009919 600922216094279 17  31
16002765 6030664 6315217 6063?·6 6031669 6023890 6029102 6013858 6055365 17  32
603172716065361160434261607156·7 6065015 6037219 6041683 6039316 6058760 17  33
6035651 6035670 6032561 60251 6 6022126 6002326 6001940 6002095 6001996 17  34
6001366 6026067 6036012 30121·<16000502 600001916000099160000021600001 17  35
1600002160000271630008216011?·1      0       0       0       0       0 17  36
8111850 4055575 6014227 59325·1 6064302 6017023 6004075 601833616093176 17  37
16009014 6029620 6033269 6062675 6031391 6026892 6030921 6012976 6050689 17  38
6031872160596941609097716036219 6065255 6037304 6041765 6039372 6059535 17  39
6035740 6035760 6032657 60251·6 6022152 6002327 6001942 6002098 6001975 17  40
6001345 6011012 6036056 30121·2160030506 6000025 600001116000002160000002 17  41
150000011600000216030001160000·0      0       0       0       0       0 17  42
8111900 4055537 6019626 59339·0 6047763 600892616003965 601331616094670 17  43
16015387 6025457 6331623 60416·5 6032038 6025641 6034053 6012699 6046674 17  44
602965916053974160759661663570 6066265 6037386 6041535 6039427 6061538 17  45
6035823 6035866 6032765 60252·5 6022130 6002328 6001942 6002099 6001991 17  46
6001346 6017726 6036650 30121 <1630058216000021160001011600000316000003 17  47
150000021600000716300082150000·1      0       0       0       0       0 17  48
8111910 4055490 6014911 5035119 6048835160011631 6012136 600798315097617 17  49
16020606 6021569 6027790 60356·5 6030369 6026560 6036183 6013471 6045221 17  50
602980116059357160729721605356·6 6048431 6037651 6041921 6039479 6060147 17  51
6035906 6035925 6032429 60253·7 6022102 6002328 6001943 6002102 6001983 17  52
6001365 6026692 6036454 30121·216000683 6000140160001011600000216000001 17  53
16000001160000721600000216000? 1      0       0       0       0       0 17  54
8122700 4039877 5936350 60857·016031255616023719160471461605543216077935 17  55
6008844 6062466 6019152160219·0 604237016053862 6039225 6040309 6066727 17  56
16003822150110661501655716052?·9 6019347 6047666 6051193 6047666 6047004 17  57
6066079 6065861 6066020 60411·6 6025805 6003223 6002304 6003360 6002023 17  58
6001561 6061192 6039139 30121·2 6356117 60002511600009616000002160000002 17  59
150900021600000716060001160000·1      0       0       0       0       0 17  60
8122710 4039827 5953461 50105·6 630866816012665160473451604612116067071 17  61
6051369 6063647 6012956 60001·6 6035768160351 36 6033475 6023971 6100043 17  62
603523815011651150166061632070·6 6048076 6047454 6051205 6047452 6066974 17  63
6066087 6045861 6066076 60411·7 6025857 6003226 6002807 6003364 6002025 17  64
6001563 6019143 6039132 30121·2 6054171 600028516000029160000031600001 17  65
16090002160119031630000216000·2      1       0       0       0       0 17  66
8122720 4034776 5070666 50156·0 602386916008717150330001605367416030576 17  67
6037619 6046475 6020616 6000?·3 603955516023759 6022979 6019737 6087838 17  68
6066301150103271501605615027?·7 6652591 6047666 6051206 6047461 6046867 17  69
6066099 6065864 6066066 60411·2 6025869 6003229 6002809 6003369 6002033 17  70
600154116001366 6033136 30121·2 6054073 60003671600008716000003160000002 17  71
16000002160130031630000216000·2      0       0       0       0       0 17  72
8122730 4039735 4310005 5029217 6045773 600537016022135160461151603 2366 17  73
6050478 6035665 6035065 60042·4 602097916001624 6008873 6022514 6066110 17  74
6079626161052361609202516017412 6025749 6047476 6051220 6047470 6046878 17  75
6066110 6045857 6066052 60411·3 6025870 6003231 6002814 6003374 6002053 17  76
6001542169140 33 6039123 30121·2 6054054 60003711600089160000031600002 17  77
16000002160000821600000216000·0      0       0       0       0       0 17  78
8122740 4039791 4311716 5023??1 6051219 6010743160236151602622016080206 17  79
6043634 6027859 6033737 60236·3 6013105 6014119 6096653 6021524 6064349 17  80
605746316091264161004841503327·0 6022521 6047477 6051247 6047479 6046851 17  81
6046120 6045869 6046069 60411·6 6025911 6003236 6002817 6003378 6002029 17  82
600154416015821 6039126 30121·2 6054157 60006381600011116000003160000002 17  83
15000002150000021630000315000·2      0       6       0       0       0 17  84
8122750 4039669 4312771 59253·· 6054671 6015905160204721601554416106265 17  85
6029548 5026141 6030486 -6322?13 6011631 6018999 6008068 6017932 6060269 17  86
6068880160796751609927716030?6· 6024790 6047687 6051252 6047488 6046911 17  87
6046127 6045869 6046065 6041172 6025921 6003237 6002821 6003383 6002018 17  88
6001544163101 44 6039137 30121·2 6054025 6000143160001501600002160000002 17  89
16000002160006041609000311600000·1      0       0       0       0       0 17  90
```

MEASUREMENT OF (A) DEAD WEIGHT OF FUEL BED SECTION AND

(B) ZERO OF OXYGEN METER

MEASUREMENT OF (A) THE WEIGHT OF FUEL BED SECTION

AND THE FUEL CHARGED, AND (B) THE OXYGEN METER

OUTPUT FOR 21 PERCENT OXYGEN

```
8122800 6034643 6011234 56269.5 6063930 6021338160153041600826115115423 17   91
6013772 6022563 6127214 60352.2 6013643 6020873 6011422 6013474 6055720 17   92
60425541607114316030471601064 .1 6033686 6047437 6051241 6047432 6046570 17   93
6046132 6045843 6044664 604411.1 6025414 6003261 6002821 6003348 6002039 17   94
6001563160024031614117 30121.2 6036046 6000302160001631600000216000002 17   95
16000002160000021600000116000.1       0       0       0       0       0 17   96
8122810 6034616 6011444 50273.5 6067242 6026374160103631600325316076049 17   97
6013380 6025260 6021624 62384.4 6012348 6020833 6020251 6007369 6055335 17   98
60375221606463216046661602660.1 6053679 6047497 6051238 6047495 6046839 17   99
6046133 6045844 6044679 60411.0 6025938 6003264 6002424 6003192 6002039 17  100
6001566 6012432 6035134 30121.2 6056163 6000459160001571600000416000001 17  101
16000002160000221600000016000.1       0       0       0       0       0 17  102
8122820 6030447 6013491 50245.4 6044313 602722416006176 600142516090079 17  103
6012186 6023746 6014913 60356.4 6013939 6017630 6023297 6007367 6046268 17  104
60490311606595216174251160341.7 6047206 6047503 6051247 6047506 6046812 17  105
6046137 6045463 6044477 60411.7 6025466 6003266 6002827 6003396 6002034 17  106
6001546 6017863 6034163 30121.2 6036036 6000277160001821600000416090001 17  107
16000002160000921600300116000.1       0       0       0       0       0 17  108
8125960 3012563 6001134 60121.1 6001365 6001205 6001230 6001159 6001195 17  109
6001088 6001170 6001144 60012.3 6001157 6001233 6001243 6001359 6001295 17  110
6001302 6001304 6001236 60013.2 6001235 6044411 6052349 6048504 6049525 17  111
6047020 6046864 6045819 6042616 6026119 6003813 6003391 6004078 6002033 17  112
6001651 6019837 6033104 30121.2 6027423 6037860 6000113160000031600000 2 17  113
16000002160000316300031160000.1       0       0       0       0       0 17  114
8125950 3012569 6001142 60121.6 6001367 6001206 6001230 6001161 6001194 17  115
6001087 6001169 6001164 60012.3 6001164 6001240 6001243 6001354 6001295 17  116
6001303 6001307 6001235 60013.2 6001295 6044413 6052338 6048502 6049511 17  117
6047019 6046646 6045911 6042610 6025156 6003814 6003302 6004082 6002006 17  118
600165216012543 6039113 30121.1 6027453 6037696 6000122160000031600000 2 17  119
16000002160000316000222160010.2       0       0       0       0       0 17  120
8130000 3012563 6001131 60012.4 6001366 6001205 6001230 6001161 6001194 17  121
6001088 6001170 6001145 60012.4 6001157 6001240 6001243 6001359 6001296 17  122
6001303 6001303 6001235 60013.1 6001295 6044414 6052334 6048500 6049506 17  123
6047021 6046868 6045011 6042617 6026186 6003814 6003305 6004086 6002019 17  124
600165016027096 6039131 30121.1 6027440 6037612 6000092160000031600000 2 17  125
16000001160000221600002160000.2       0       0       0       0       0 17  126
8130010 3012560 6001144 60012.0 6001366 6001205 6001229 6001159 6001194 17  127
6001087 6001170 6001143 60012.3 6001168 6001239 6001243 6001360 6001296 17  128
6001303 6001394 6001231 60013.3 6001245 6044421 6052350 6048504 6049484 17  129
6047019 6046852 6045012 6042626 6025148 6003821 6003308 6004088 6002012 17  130
600165416034188 6033125 30121.2 6027418 6037630 6000093160000031600000 2 17  131
16000001160000231600003116000.2       0       0       0       0       0 17  132
8130020 3012561 6001175 60011.3 6001367 6001200 6001226 6001153 6001192 17  133
6001077 6001167 6001137 60012.4 6001170 6001240 6001242 6001360 6001296 17  134
6001304 6001394 6001224 60013.2 6001296 6044422 6052359 6048508 6049489 17  135
6047023 6046863 6045814 6042631 6026227 6003825 6003309 6004090 6002006 17  136
600165316033143 6039126 30121.2 6027743 6037754 6000094160000031600000 2 17  137
16000002160000931600000216000.1       0       0       0       0       0 17  138
8130039 3012569 6001165 60011.4 6001368 6001200 6001224 6001153 6001190 17  139
6001049 6001162 6001134 60012.4 6001171 6001240 6001243 6001359 6001296 17  140
6001304 6001394 6001222 60013.4 6001296 6044422 6052343 6048515 6049457 17  141
6047027 6046861 6045914 6042634 6026190 6003824 6003309 6004092 6002043 17  142
600165416036350 6139119 30121.1 6027292 6037739 6000151160000031600000 1 17  143
16000001160000931600070216000.1       0       0       0       0       0 17  144
8130040 3012563 6001163 60011.2 6001368 6001200 6001224 6001153 6001187 17  145
6001062 6001153 6001132 60012.4 6001174 6001240 6001243 6001360 6001296 17  146
6001303 6001395 6001222 60013.2 6001295 6049425 6052150 6048523 6049408 17  147
6047054 6046862 6045817 6042627 6024876 6003833 6003329 6004093 6002036 17  148
600165516032187 6039041 30121.2 6027635 6037651 6000043160000041600000 2 17  149
16000001160000331600003160000.1       0       0       0       0       0 17  150
8130050 6044299 6001147 60011.9 6001366 6001201 6001221 6001154 6001186 17  151
6001056 6001156 6001129 60012.4 6001176 6001241 6001244 6001359 6001296 17  152
6001304 6001304 6001227 60013.3 6001247 6047473 6051504 6048279 6048562 17  153
6046841 6046599 6044980 6042549 6022518 6003837 6003341 6004099 6002043 17  154
600165316011836 6039041 30121.1 6029908 6016180 6000105160000041600000 3 17  155
16000001160000021600002160010.1       0       0       0       0       0 17  156
8130100 6064268 6001174 60012.5 6001367 6001201 6001220 6001153 6001184 17  157
6001051 6001157 6001124 60012.3 6001176 6001240 6001243 6001361 6001297 17  158
6001303 6001364 6001231 60013.3 6001249 6046967 6050495 6047740 6046817 17  159
6046383 6046096 6044626 6042373 6021045 6003866 6003351 6004105 6002056 17  160
600165516009796 6039044 30121.1 6048350 6002578 6000037160000031600000 1 17  161
16000001160000021600000016000.1       0       0       0       0       0 17  162
8130110 6064185 6001144 6001211 6001347 6001200 6001218 6001155 6001182 17  163
6001068 6001151 6001123 60012.4 6001179 6001240 6001244 6001361 6001297 17  164
6001303 6001396 6001236 60013.3 6001247 6044074 6049494 6047131 6045766 17  165
6045871 6045529 6044275 6042114 6020165 6003850 6003362 6004111 6002057 17  166
6001656 6004721 6039971 30121.2 6052663 6001262 6000150160000041600000 1 17  167
16000001160000021600000115000.1       0       0       0       0       0 17  168
8130120 4068944 6001291 6001217 6001367 6001200 6001218 6001153 6001180 17  169
6001045 6001165 6001121 60012.4 6001178 6001240 6001244 6001361 6001297 17  170
6001304 6001364 6001241 60013.4 6001299 6045261 6048594 6046525 6044927 17  171
6045357 6044969 6043494 6041920 6019319 6003851 6003369 6004119 6002026 17  172
6001657 6014533 6033936 30121.1 6052072 6001360 6000212150000041600000 2 17  173
16000002160000031600000016000.1       0       0       0       0       0 17  174
8130130 6059016 6001211 60012.0 6001368 6001201 6001219 6001153 6001179 17  175
6001062 6001143 6001120 60012.4 6001179 6001240 6001244 6001361 6001296 17  176
6001304 6001365 6001245 60013.2 6001399 6044474 6047787 6045936 6044089 17  177
6044860 6044335 6043594 6041647 6018606 6003854 6003374 6004122 6002018 17  178
6001658 6003920 6039071 30121.1 6053012 6001424 6000138160000031600000 2 17  179
16000002160000031600000216000.0       0       0       0       0       0 17  180
8130140 6047938 6001226 60012.3 6001366 6001201 6001215 6001152 6001176 17  181
6001039 6001149 6001113 60012.3 6001193 6001241 6001243 6001363 6001297 17  182
6001305 6001363 6001241 60013.6 6001300 6043771 6047062 6045374 6043232 17  183
6044388 6043869 6043113 6041443 6014199 6003850 6003378 6004125 6002045 17  184
```

DATA ACQUISITION SYSTEM TURNED ON BEFORE START OF RUN

RUN STARTED

## TABLE H.III

### Listing of Temperatures, Gas Compositions and Fuel Bed Weight Loss for Run 17 (Output from DATA REDUCTION 2)

```
                                          RUN NUMBER = 17

                                 RUN STARTED AT TIME =   0.130050E 04


                   UNDERFIRE AIR AT FINAL VALUE AT TIME =   0.131320E 04
          NUMBER OF READINGS OF 0 PERCENT O2 AND DEAD WT. =   9.0
         NUMBER OF READINGS OF 21 PERCENT O2 AND TOTAL WT. =   9.0


INDICATION CHANNEL LIGHT GREEN, AMBER AND RED (NUMBER) AND TIME (  1, 10, 26)  0.111750E 04  0.122700E 04  0.130050E 04
```

| Channel Number | Instrument Location | | |
|---|---|---|---|
| 163 | Overfire Section Inside Refractory Thermocouple 2 | | See Fig. A.5 for location |
| 164 | Overfire Section Inside Refractory Thermocouple 3 | | |
| 165 | Overfire Section Inside Refractory Thermocouple 4 | | |
| 166 | Overfire Section Inside Refractory Thermocouple 5 | | |
| 167 | Overfire Section Inside Refractory Thermocouple 6 | | |
| 168 | Overfire Section Inside Refractory Thermocouple 7 | | |
| 169 | Overfire Section Inside Refractory Thermocouple 8 | | |
| 170 | Stack gas temperature | | |
| 171 | Overfire Section Shell Thermocouple 1 | | |
| 172 | Overfire Section Shell Thermocouple 2 | | |
| 173 | Overfire Section Shell Thermocouple 3 | | |
| 174 | Inlet air temperature in distribution plenuum | | |
| 175 | Sliding Refractory Shield (inside surface) | | |
| 176 | Smoke Meter (not used in Runs 17, 18) | | |
| 177 | Load Cell Output | | |
| 178 | Load Cell Input | | |
| 179 | Stack Gas Probe (on line analysis) | Oxygen | |
| 180 | | Carbon Dioxide | |
| 181 | | Carbon Monoxide | |
| 182 | Fuel Bed Probe 1 (20 inches from grate) (on line analysis) | Oxygen | |
| 183 | | Carbon Dioxide | |
| 184 | | Carbon Monoxide | |
| 185 | Fuel Bed Probe 2 (12 inches from grate) (on line analysis) | Oxygen | |
| 186 | | Carbon Dioxide | |
| 187 | | Carbon Monoxide | |

```
                 TABLE OF TEMPERATURES (EXCLUDING FUEL BED) IN DEG. FAHRENHEIT

FROM THE CHROMEL-ALUMEL TABLE

THE REFERENCE VOLTAGE IN MILLIVOLTS IS    0.0

    TIME            153            154            155            156            157            158            159            160
0.130050E 04  0.873995E 02  0.875231E 02  0.925082E 02  0.897890E 02  0.901186E 02  0.901186E 02  0.867815E 02  0.913774E 02
0.130100E 04  0.873583E 02  0.874819E 02  0.925494E 02  0.898302E 02  0.900774E 02  0.901186E 02  0.869463E 02  0.900774E 02
0.130110E 04  0.873583E 02  0.875231E 02  0.925906E 02  0.898302E 02  0.900774E 02  0.901186E 02  0.871935E 02  0.900774E 02
0.130120E 04  0.873583E 02  0.875231E 02  0.925494E 02  0.898302E 02  0.901186E 02  0.901186E 02  0.873995E 02  0.901186E 02
0.130130E 04  0.873583E 02  0.875231E 02  0.925906E 02  0.897890E 02  0.901186E 02  0.901598E 02  0.875643E 02  0.901598E 02
0.130140E 04  0.873995E 02  0.874819E 02  0.926318E 02  0.898302E 02  0.901598E 02  0.900774E 02  0.877291E 02  0.902010E 02
0.130150E 04  0.873583E 02  0.875231E 02  0.926318E 02  0.898714E 02  0.901186E 02  0.900774E 02  0.878527E 02  0.902010E 02
0.130200E 04  0.873583E 02  0.874819E 02  0.926730E 02  0.897890E 02  0.901598E 02  0.901186E 02  0.880587E 02  0.902010E 02
0.130210E 04  0.873583E 02  0.875231E 02  0.926730E 02  0.898302E 02  0.901598E 02  0.901186E 02  0.880999E 02  0.902422E 02
0.130220E 04  0.873583E 02  0.874819E 02  0.926318E 02  0.898302E 02  0.901186E 02  0.901186E 02  0.881411E 02  0.902422E 02
0.130230E 04  0.873583E 02  0.875231E 02  0.926318E 02  0.898302E 02  0.901186E 02  0.900362E 02  0.881823E 02  0.902422E 02
0.130240E 04  0.873995E 02  0.875231E 02  0.926318E 02  0.898714E 02  0.901598E 02  0.900774E 02  0.881411E 02  0.902834E 02
0.130250E 04  0.873171E 02  0.874819E 02  0.926730E 02  0.898714E 02  0.901186E 02  0.900362E 02  0.881411E 02  0.902422E 02
0.130300E 04  0.873583E 02  0.875231E 02  0.926730E 02  0.898714E 02  0.902010E 02  0.899950E 02  0.880999E 02  0.902834E 02
0.130310E 04  0.873583E 02  0.874819E 02  0.927142E 02  0.898714E 02  0.901186E 02  0.900362E 02  0.880587E 02  0.902422E 02
0.130320E 04  0.873995E 02  0.875643E 02  0.927142E 02  0.898714E 02  0.902010E 02  0.900362E 02  0.879351E 02  0.903246E 02
0.130330E 04  0.873583E 02  0.875231E 02  0.927142E 02  0.898714E 02  0.901598E 02  0.899950E 02  0.878939E 02  0.902834E 02
0.130340E 04  0.873583E 02  0.875231E 02  0.926730E 02  0.898302E 02  0.901598E 02  0.899538E 02  0.878939E 02  0.902834E 02
0.130350E 04  0.873171E 02  0.875231E 02  0.926730E 02  0.898302E 02  0.901186E 02  0.899538E 02  0.877703E 02  0.902422E 02
0.130400E 04  0.873583E 02  0.875231E 02  0.927966E 02  0.898714E 02  0.902422E 02  0.899538E 02  0.877291E 02  0.903246E 02
0.130410E 04  0.873995E 02  0.875231E 02  0.927142E 02  0.898714E 02  0.901186E 02  0.899950E 02  0.877291E 02  0.902834E 02
0.130420E 04  0.873583E 02  0.875231E 02  0.927554E 02  0.897890E 02  0.901186E 02  0.899538E 02  0.876467E 02  0.903658E 02
0.130430E 04  0.873995E 02  0.875231E 02  0.926730E 02  0.898302E 02  0.902010E 02  0.899950E 02  0.876467E 02  0.902834E 02
0.130440E 04  0.873583E 02  0.875231E 02  0.927554E 02  0.899126E 02  0.901598E 02  0.899950E 02  0.876055E 02  0.903246E 02
0.130450E 04  0.873995E 02  0.875231E 02  0.927554E 02  0.898714E 02  0.902010E 02  0.899126E 02  0.875643E 02  0.903658E 02
0.130500E 04  0.874407E 02  0.874819E 02  0.927554E 02  0.898714E 02  0.902010E 02  0.899126E 02  0.875231E 02  0.902834E 02
0.130510E 04  0.873995E 02  0.875231E 02  0.927554E 02  0.899126E 02  0.902010E 02  0.899538E 02  0.875231E 02  0.903246E 02
0.130520E 04  0.873583E 02  0.875643E 02  0.927142E 02  0.898714E 02  0.902422E 02  0.899126E 02  0.874819E 02  0.903658E 02
0.130530E 04  0.873583E 02  0.875643E 02  0.927554E 02  0.898714E 02  0.902010E 02  0.899538E 02  0.874407E 02  0.903658E 02
0.130540E 04  0.873995E 02  0.874819E 02  0.927966E 02  0.899126E 02  0.901598E 02  0.899126E 02  0.874407E 02  0.903658E 02
0.130550E 04  0.873995E 02  0.875643E 02  0.927966E 02  0.898714E 02  0.902010E 02  0.899126E 02  0.874407E 02  0.903658E 02
0.130600E 04  0.873995E 02  0.875231E 02  0.927554E 02  0.899126E 02  0.902422E 02  0.899126E 02  0.874819E 02  0.904070E 02
0.130610E 04  0.873583E 02  0.875231E 02  0.927966E 02  0.899126E 02  0.902010E 02  0.898714E 02  0.874819E 02  0.903658E 02
0.130620E 04  0.873995E 02  0.875231E 02  0.927966E 02  0.898714E 02  0.901598E 02  0.899126E 02  0.875643E 02  0.904070E 02
0.130630E 04  0.873583E 02  0.875643E 02  0.928378E 02  0.899126E 02  0.902010E 02  0.899126E 02  0.876055E 02  0.903658E 02
0.130640E 04  0.873995E 02  0.875643E 02  0.927966E 02  0.898714E 02  0.902422E 02  0.899538E 02  0.876055E 02  0.904070E 02
0.130650E 04  0.873583E 02  0.875643E 02  0.927554E 02  0.899126E 02  0.902422E 02  0.899538E 02  0.876879E 02  0.904070E 02
0.130700E 04  0.873995E 02  0.875643E 02  0.927966E 02  0.899538E 02  0.902834E 02  0.899538E 02  0.876467E 02  0.904482E 02
0.130710E 04  0.874407E 02  0.876055E 02  0.928378E 02  0.899538E 02  0.902010E 02  0.899950E 02  0.877291E 02  0.904482E 02
0.130720E 04  0.873583E 02  0.875231E 02  0.927966E 02  0.899126E 02  0.902422E 02  0.899538E 02  0.877291E 02  0.904070E 02
0.130730E 04  0.873583E 02  0.875231E 02  0.928378E 02  0.899538E 02  0.902422E 02  0.899538E 02  0.878115E 02  0.904482E 02
0.130740E 04  0.873995E 02  0.875643E 02  0.927966E 02  0.899126E 02  0.902422E 02  0.899538E 02  0.878527E 02  0.904894E 02
0.130750E 04  0.873583E 02  0.875231E 02  0.928378E 02  0.899950E 02  0.902422E 02  0.899538E 02  0.878527E 02  0.904894E 02
0.130800E 04  0.874819E 02  0.875643E 02  0.928378E 02  0.899950E 02  0.902422E 02  0.899538E 02  0.879351E 02  0.904482E 02
0.130810E 04  0.873583E 02  0.874819E 02  0.928378E 02  0.899538E 02  0.902422E 02  0.899538E 02  0.879763E 02  0.904482E 02
0.130820E 04  0.873995E 02  0.875643E 02  0.928790E 02  0.899950E 02  0.902834E 02  0.899950E 02  0.878939E 02  0.904894E 02
0.130830E 04  0.874407E 02  0.876055E 02  0.929202E 02  0.899538E 02  0.902834E 02  0.899538E 02  0.878939E 02  0.905306E 02
0.130840E 04  0.873583E 02  0.875643E 02  0.928378E 02  0.899126E 02  0.903246E 02  0.899126E 02  0.878527E 02  0.905718E 02
0.130850E 04  0.873995E 02  0.875643E 02  0.928790E 02  0.899950E 02  0.903246E 02  0.899126E 02  0.878115E 02  0.904894E 02
0.130900E 04  0.874819E 02  0.875643E 02  0.928378E 02  0.900362E 02  0.902834E 02  0.899538E 02  0.877703E 02  0.904894E 02
0.130910E 04  0.874407E 02  0.875643E 02  0.928790E 02  0.899538E 02  0.902834E 02  0.898714E 02  0.878115E 02  0.905306E 02
0.130920E 04  0.873995E 02  0.876055E 02  0.928378E 02  0.899538E 02  0.902834E 02  0.899126E 02  0.878527E 02  0.905306E 02
0.130930E 04  0.874407E 02  0.876055E 02  0.928378E 02  0.899950E 02  0.903246E 02  0.899126E 02  0.878939E 02  0.904894E 02
0.130940E 04  0.873583E 02  0.875643E 02  0.928790E 02  0.899950E 02  0.903246E 02  0.898714E 02  0.878527E 02  0.904482E 02
0.130950E 04  0.874407E 02  0.876467E 02  0.928790E 02  0.899950E 02  0.902834E 02  0.899126E 02  0.878939E 02  0.905306E 02
0.131000E 04  0.873995E 02  0.876055E 02  0.928378E 02  0.900362E 02  0.903658E 02  0.899126E 02  0.879351E 02  0.905306E 02
0.131010E 04  0.874407E 02  0.875643E 02  0.929202E 02  0.900362E 02  0.903246E 02  0.898714E 02  0.879763E 02  0.905306E 02
0.131020E 04  0.874407E 02  0.876055E 02  0.929202E 02  0.899950E 02  0.903246E 02  0.898714E 02  0.880587E 02  0.905306E 02
0.131030E 04  0.874407E 02  0.876055E 02  0.929202E 02  0.900362E 02  0.903246E 02  0.899126E 02  0.881411E 02  0.905718E 02
0.131040E 04  0.874407E 02  0.875643E 02  0.929202E 02  0.899950E 02  0.903246E 02  0.899126E 02  0.881411E 02  0.904894E 02
0.131050E 04  0.874819E 02  0.876055E 02  0.929202E 02  0.900362E 02  0.903246E 02  0.899126E 02  0.882647E 02  0.905718E 02
0.131100E 04  0.874407E 02  0.875643E 02  0.929202E 02  0.900362E 02  0.903246E 02  0.898714E 02  0.882647E 02  0.905718E 02
0.131110E 04  0.873995E 02  0.876055E 02  0.929202E 02  0.900774E 02  0.903658E 02  0.898714E 02  0.883883E 02  0.904894E 02
0.131120E 04  0.874407E 02  0.876055E 02  0.929613E 02  0.900774E 02  0.903246E 02  0.898714E 02  0.883883E 02  0.905718E 02
0.131130E 04  0.874407E 02  0.876055E 02  0.929202E 02  0.900774E 02  0.903246E 02  0.899126E 02  0.884707E 02  0.906130E 02
0.131140E 04  0.874819E 02  0.876055E 02  0.929613E 02  0.900362E 02  0.903658E 02  0.899538E 02  0.884707E 02  0.905306E 02
0.131150E 04  0.874819E 02  0.876055E 02  0.930025E 02  0.900774E 02  0.903658E 02  0.899126E 02  0.885531E 02  0.905718E 02
0.131200E 04  0.873995E 02  0.876055E 02  0.929202E 02  0.900774E 02  0.903658E 02  0.899538E 02  0.886355E 02  0.906130E 02
0.131210E 04  0.874819E 02  0.876055E 02  0.929202E 02  0.900362E 02  0.904482E 02  0.899126E 02  0.886355E 02  0.906130E 02
0.131220E 04  0.874819E 02  0.876055E 02  0.930025E 02  0.900774E 02  0.904070E 02  0.898714E 02  0.887179E 02  0.906130E 02
0.131230E 04  0.874407E 02  0.876467E 02  0.930025E 02  0.901186E 02  0.904070E 02  0.898714E 02  0.888003E 02  0.905718E 02
0.131240E 04  0.874819E 02  0.876055E 02  0.930025E 02  0.901186E 02  0.904070E 02  0.899126E 02  0.888827E 02  0.905718E 02
0.131250E 04  0.874819E 02  0.876467E 02  0.930025E 02  0.901186E 02  0.904482E 02  0.899126E 02  0.890063E 02  0.906130E 02
0.131300E 04  0.874407E 02  0.876055E 02  0.930025E 02  0.901598E 02  0.904070E 02  0.899126E 02  0.891294E 02  0.906130E 02
0.131310E 04  0.874407E 02  0.876055E 02  0.930437E 02  0.901598E 02  0.904482E 02  0.899538E 02  0.891299E 02  0.906542E 02
0.131320E 04  0.874819E 02  0.876055E 02  0.930437E 02  0.901186E 02  0.904894E 02  0.899126E 02  0.891711E 02  0.906130E 02
0.131330E 04  0.874407E 02  0.876467E 02  0.930025E 02  0.901598E 02  0.904482E 02  0.899950E 02  0.892123E 02  0.906130E 02
0.131340E 04  0.874819E 02  0.876055E 02  0.930849E 02  0.901598E 02  0.904482E 02  0.899126E 02  0.892535E 02  0.906542E 02
0.131350E 04  0.874407E 02  0.876467E 02  0.930437E 02  0.901598E 02  0.904482E 02  0.899538E 02  0.893359E 02  0.906130E 02
0.131400E 04  0.874819E 02  0.876467E 02  0.930437E 02  0.901598E 02  0.904894E 02  0.899126E 02  0.894595E 02  0.907366E 02
0.131410E 04  0.874819E 02  0.876055E 02  0.930437E 02  0.902010E 02  0.904482E 02  0.899538E 02  0.896243E 02  0.906542E 02
0.131420E 04  0.875231E 02  0.876467E 02  0.930849E 02  0.901598E 02  0.904894E 02  0.899538E 02  0.897478E 02  0.906130E 02
0.131430E 04  0.875231E 02  0.876467E 02  0.930849E 02  0.902010E 02  0.905306E 02  0.899538E 02  0.899538E 02  0.906542E 02
0.131440E 04  0.874407E 02  0.876467E 02  0.930849E 02  0.902010E 02  0.904070E 02  0.899538E 02  0.901598E 02  0.907366E 02
0.131450E 04  0.875231E 02  0.876055E 02  0.930437E 02  0.902010E 02  0.904482E 02  0.899538E 02  0.905306E 02  0.907366E 02
0.131500E 04  0.875231E 02  0.875643E 02  0.930849E 02  0.902422E 02  0.904894E 02  0.899950E 02  0.908602E 02  0.907366E 02
0.131510E 04  0.875231E 02  0.876055E 02  0.930849E 02  0.901598E 02  0.905306E 02  0.899950E 02  0.912310E 02  0.907366E 02
0.131520E 04  0.874819E 02  0.876467E 02  0.930849E 02  0.902422E 02  0.905718E 02  0.899538E 02  0.916428E 02  0.907366E 02
0.131530E 04  0.874407E 02  0.876879E 02  0.931261E 02  0.903246E 02  0.904894E 02  0.899950E 02  0.921553E 02  0.907366E 02
0.131540E 04  0.874819E 02  0.876055E 02  0.930849E 02  0.902422E 02  0.905306E 02  0.900362E 02  0.925906E 02  0.907366E 02
0.131550E 04  0.875231E 02  0.876467E 02  0.930849E 02  0.902834E 02  0.905306E 02  0.899950E 02  0.931673E 02  0.907366E 02
0.131600E 04  0.874819E 02  0.876467E 02  0.930849E 02  0.902422E 02  0.904894E 02  0.899950E 02  0.937853E 02  0.906542E 02
0.131610E 04  0.875643E 02  0.876055E 02  0.931261E 02  0.902834E 02  0.905718E 02  0.900362E 02  0.944445E 02  0.907778E 02
0.131620E 04  0.875231E 02  0.876467E 02  0.932085E 02  0.902834E 02  0.905306E 02  0.900774E 02  0.951213E 02  0.907366E 02
0.131630E 04  0.874819E 02  0.876879E 02  0.931673E 02  0.903246E 02  0.905718E 02  0.900362E 02  0.957624E 02  0.908190E 02
0.131640E 04  0.874407E 02  0.876467E 02  0.931673E 02  0.903246E 02  0.905306E 02  0.900362E 02  0.965046E 02  0.907366E 02
0.131650E 04  0.875231E 02  0.876467E 02  0.931673E 02  0.902834E 02  0.905306E 02  0.899950E 02  0.972048E 02  0.907366E 02
0.131700E 04  0.874819E 02  0.876879E 02  0.931673E 02  0.902834E 02  0.905718E 02  0.900362E 02  0.978660E 02  0.906542E 02
0.131710E 04  0.874407E 02  0.876467E 02  0.931261E 02  0.903246E 02  0.905306E 02  0.900362E 02  0.987292E 02  0.907778E 02
0.131720E 04  0.875231E 02  0.876467E 02  0.931673E 02  0.903246E 02  0.905718E 02  0.900362E 02  0.994737E 02  0.907778E 02
0.131730E 04  0.875231E 02  0.876467E 02  0.931673E 02  0.903658E 02  0.906130E 02  0.900774E 02  0.100531E 03  0.908190E 02
0.131740E 04  0.874819E 02  0.876467E 02  0.932085E 02  0.903658E 02  0.905718E 02  0.900774E 02  0.101242E 03  0.907778E 02
0.131750E 04  0.874819E 02  0.876467E 02  0.932085E 02  0.903246E 02  0.906130E 02  0.901186E 02  0.102149E 03  0.908190E 02
0.131800E 04  0.875643E 02  0.876467E 02  0.932085E 02  0.903246E 02  0.906130E 02  0.900774E 02  0.103322E 03  0.907778E 02
0.131810E 04  0.875231E 02  0.876879E 02  0.931673E 02  0.903246E 02  0.906130E 02  0.901186E 02  0.104621E 03  0.908602E 02
0.131820E 04  0.875231E 02  0.876467E 02  0.932085E 02  0.903658E 02  0.906130E 02  0.901186E 02  0.106180E 03  0.908190E 02
0.131830E 04  0.874819E 02  0.876467E 02  0.932085E 02  0.903658E 02  0.906542E 02  0.901186E 02  0.107793E 03  0.908190E 02
0.131840E 04  0.874819E 02  0.876879E 02  0.932085E 02  0.903658E 02  0.906130E 02  0.901186E 02  0.109523E 03  0.907778E 02
0.131850E 04  0.874819E 02  0.876467E 02  0.932497E 02  0.904070E 02  0.906542E 02  0.902010E 02  0.111336E 03  0.908190E 02
0.131900E 04  0.874819E 02  0.876467E 02  0.932497E 02  0.904070E 02  0.906542E 02  0.901186E 02  0.111006E 03  0.907366E 02
0.131910E 04  0.875231E 02  0.876879E 02  0.932085E 02  0.904070E 02  0.906542E 02  0.901598E 02  0.116755E 03  0.908602E 02
0.131920E 04  0.874819E 02  0.876879E 02  0.932909E 02  0.904482E 02  0.907366E 02  0.901598E 02  0.116248E 03  0.908602E 02
0.131930E 04  0.874819E 02  0.876467E 02  0.932909E 02  0.904070E 02  0.906542E 02  0.902010E 02  0.117804E 03  0.908602E 02
0.131940E 04  0.875231E 02  0.877291E 02  0.932085E 02  0.904070E 02  0.906542E 02  0.901598E 02  0.119570E 03  0.908602E 02
0.131950E 04  0.875643E 02  0.876467E 02  0.932497E 02  0.904482E 02  0.907366E 02  0.902010E 02  0.126730E 03  0.908602E 02
0.132000E 04  0.875231E 02  0.876467E 02  0.932909E 02  0.904070E 02  0.906542E 02  0.901598E 02  0.131556E 03  0.908602E 02
0.132010E 04  0.875231E 02  0.877291E 02  0.932497E 02  0.903658E 02  0.907366E 02  0.902010E 02  0.158216E 03  0.908602E 02
0.132020E 04  0.874819E 02  0.876879E 02  0.932909E 02  0.901186E 02  0.907366E 02  0.901598E 02  0.208641E 03  0.908602E 02
```

```
[illegible]

    TIME              161              162              163              164              165              166              167              168
[illegible]
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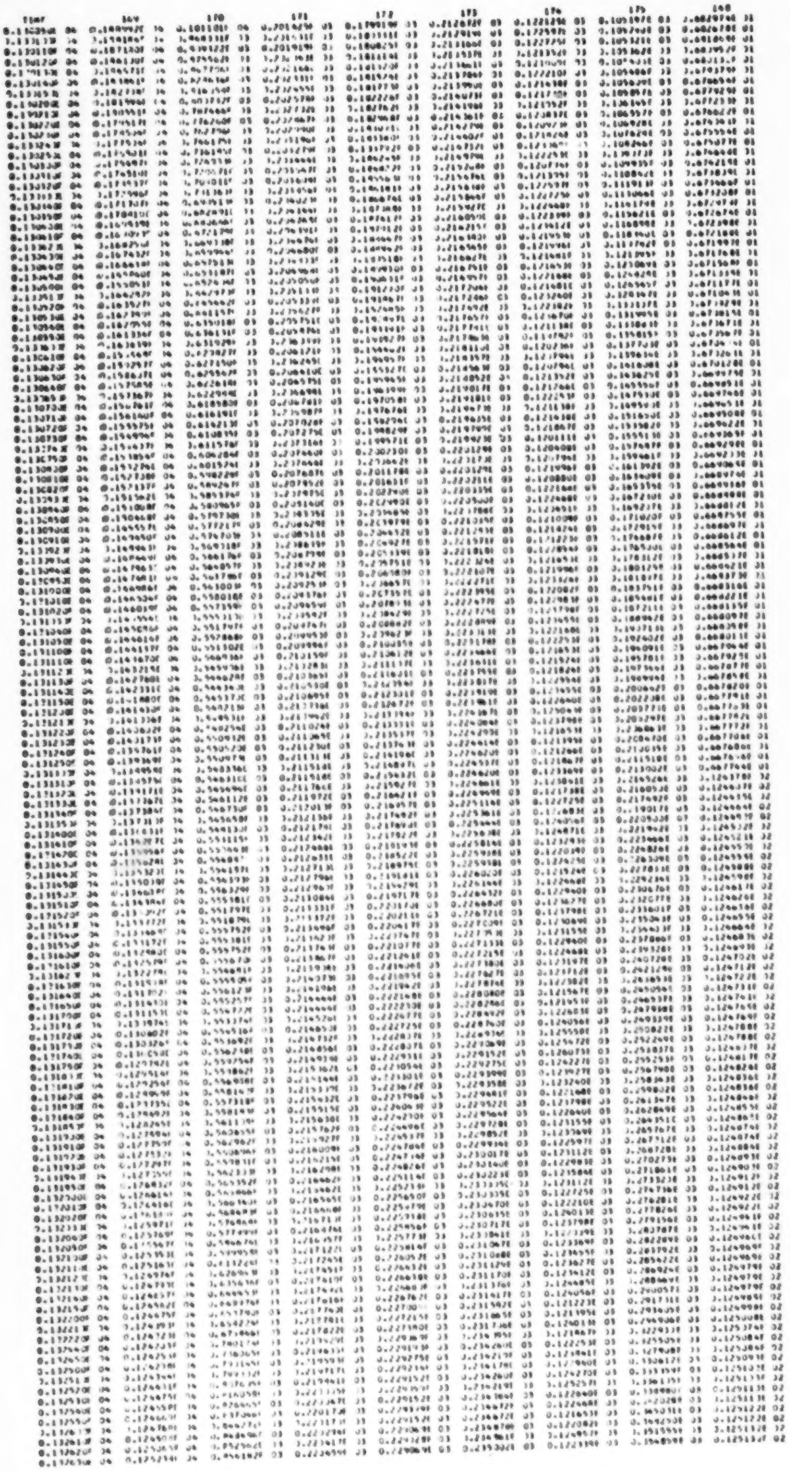

```
TIME          169            170            171            172            173            174            175            1[illegible]
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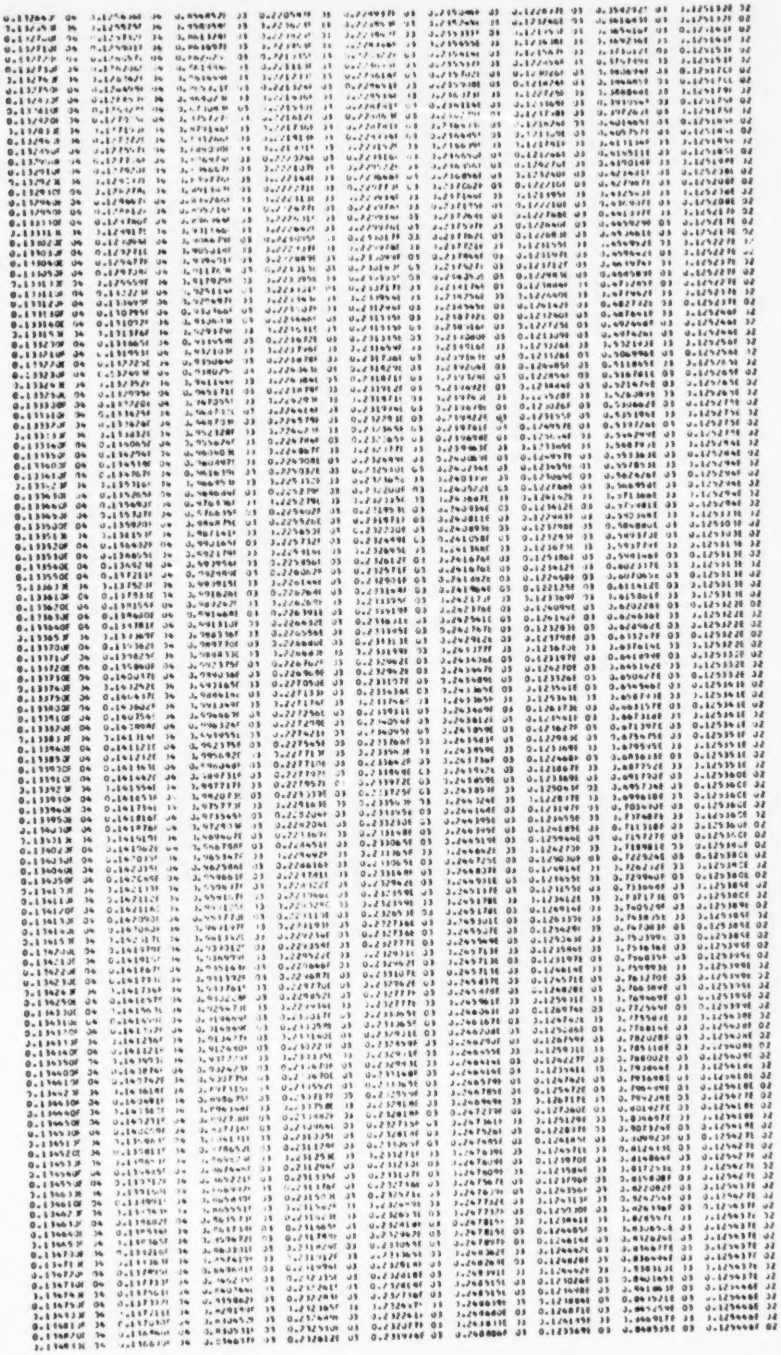


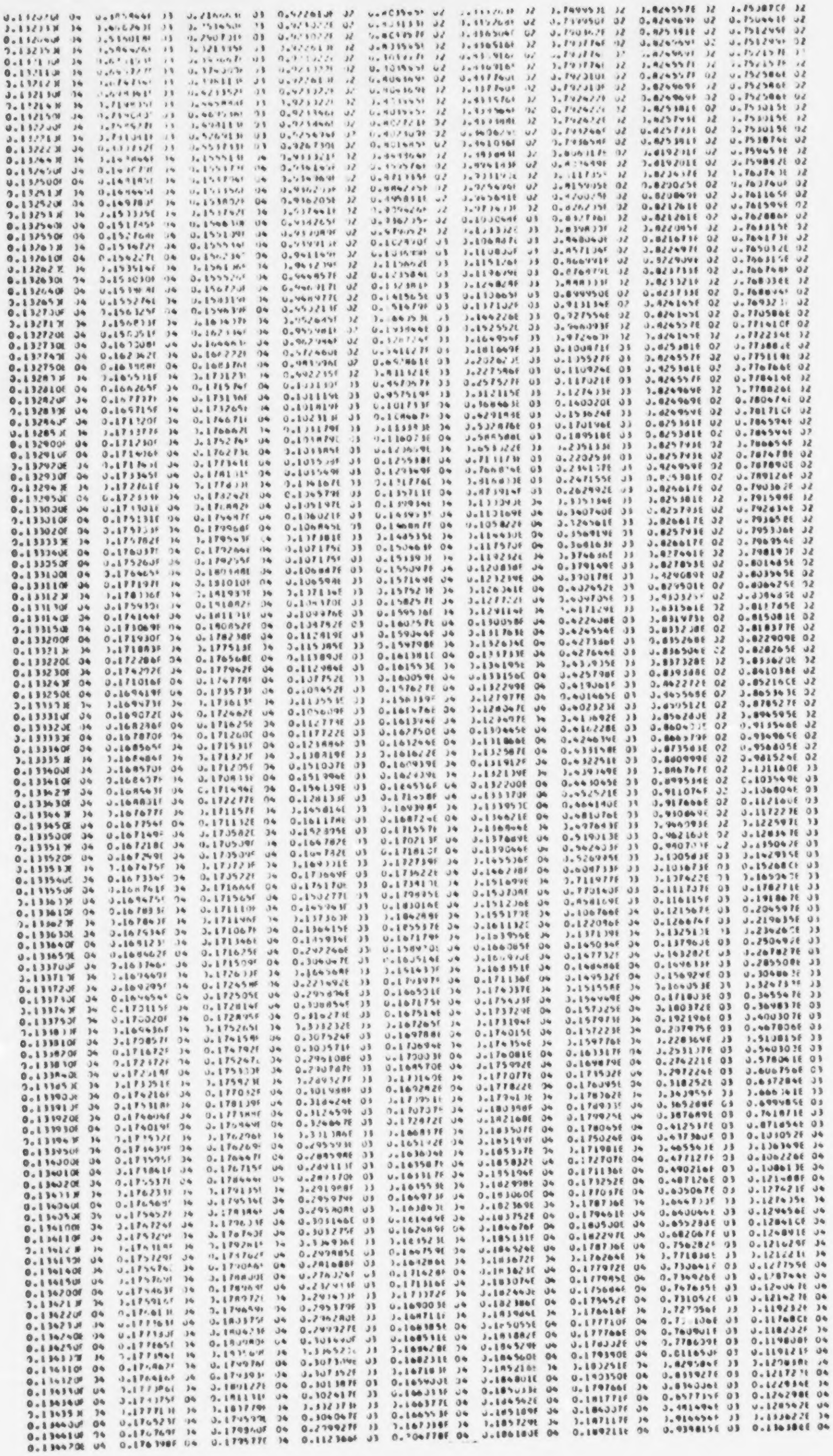
[illegible]

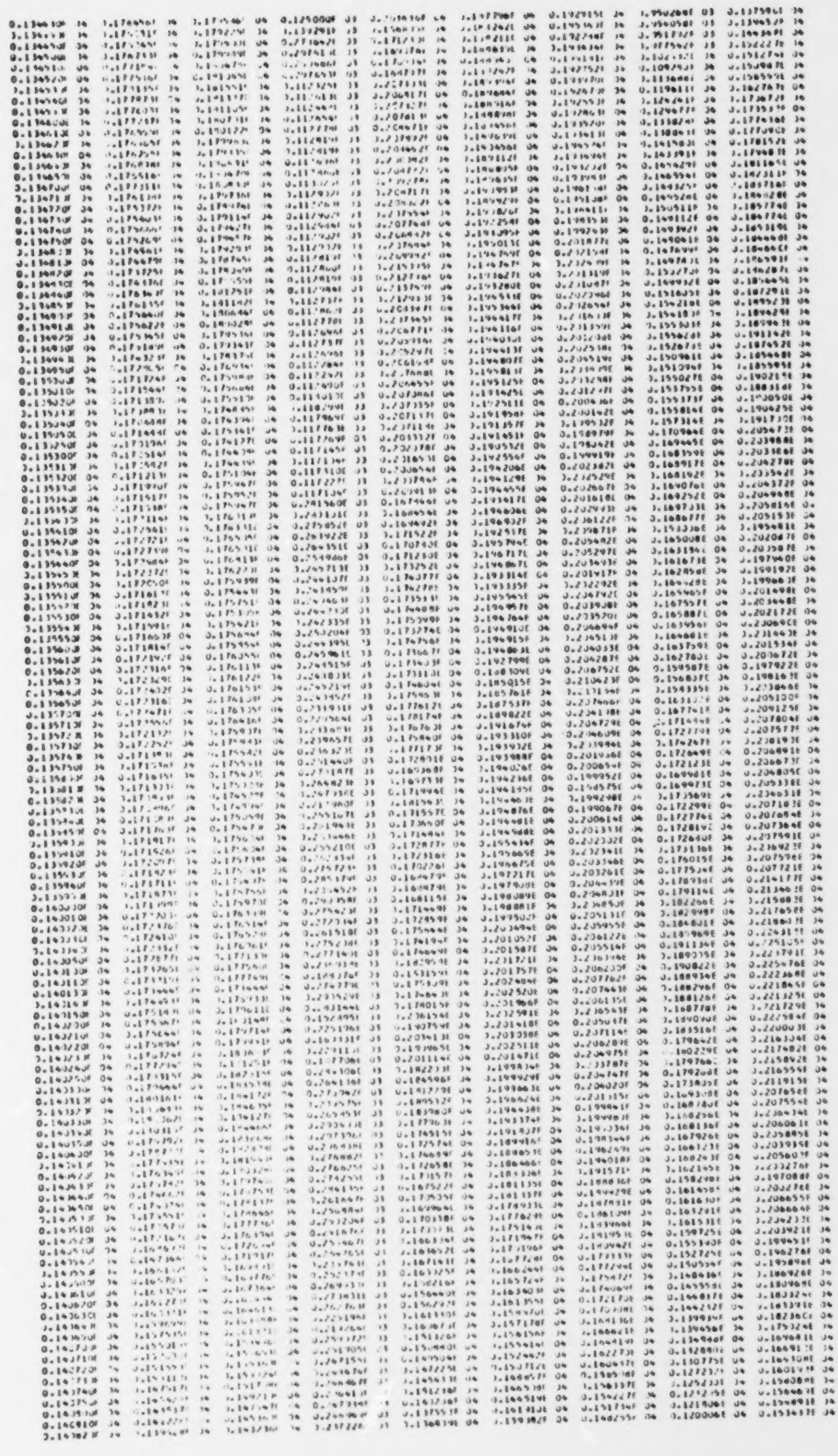
FUEL BED TEMPERATURES

```
FROM THE CHROMEL-ALUMEL TABLE

THE REFERENCE VOLTAGE IN MILLIVOLTS IS   0.0

    TIME          161           162           163           164           165           166           167           168
[illegible]
```





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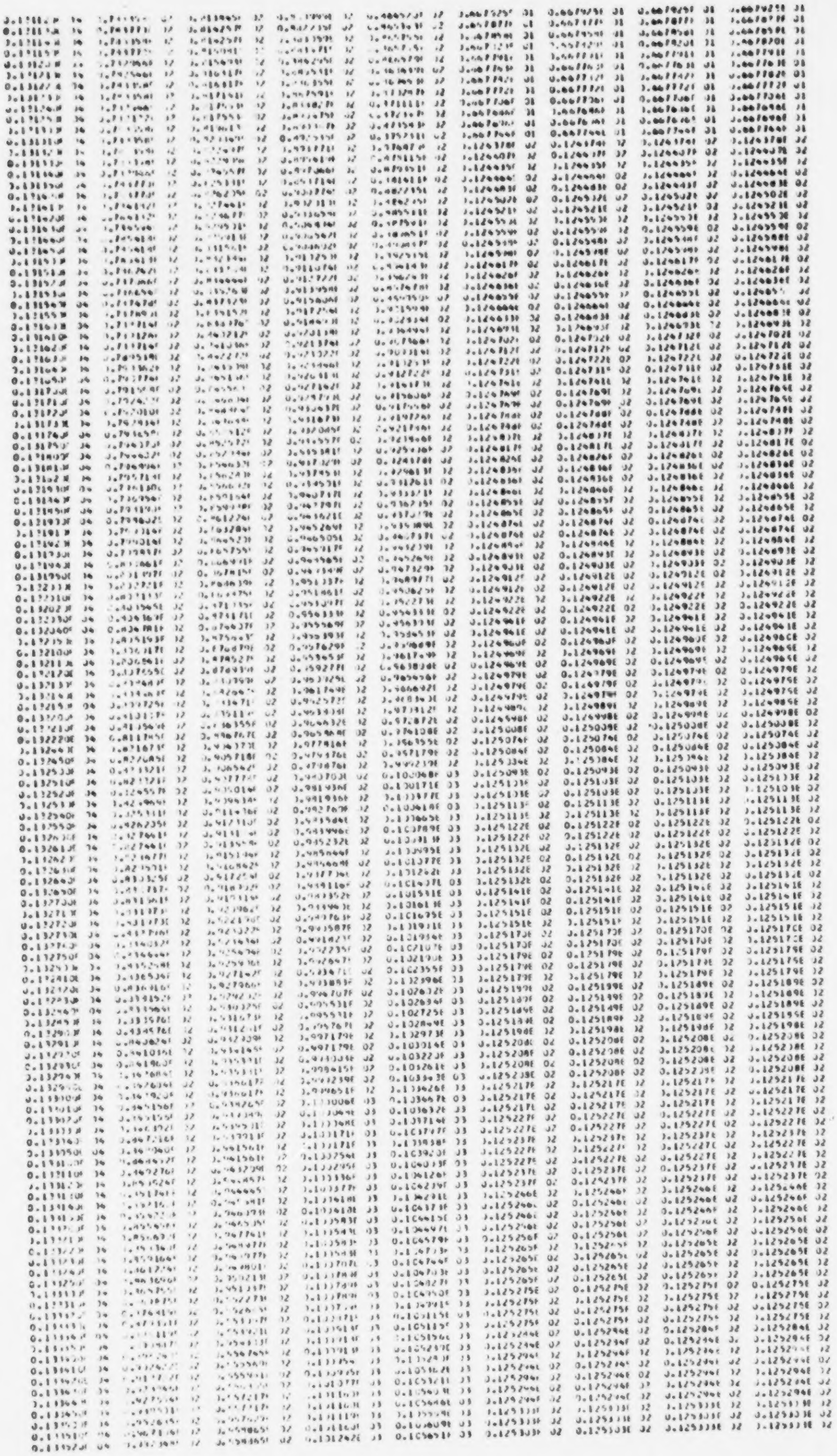
[illegible]

TIME          149             150             151             152             140             140             140             140
[illegible]
```



[illegible]

```
[illegible]
```

```
                              IGNITION WAVE PROPAGATION

DEPTH IN INCHES            TIMF IN SECONDS     TEMPERATURE IN FAHRENHEIT
          0.500000E 01            0.120402E 04         0.600000E 03
          0.700000E 01            0.129546E 04         0.600000E 03
          0.110000E 02            0.0                  0.600000E 03
          0.120000E 02            0.161327E 04         0.600000E 03
          0.150000E 02            0.169159E 04         0.600000E 03
          0.170000E 02            0.208793E 04         0.600000E 03
          0.190000E 02            0.238857E 04         0.600000E 03
          0.210000E 02            0.227741E 04         0.600000F 03
          0.230000E 02            0.242905E 04         0.600000E 03
          0.260000E 02            0.324674E 04         0.600000E 03
          0.280000E 02            0.348335E 04         0.600000E 03
          0.300000E 02            0.348110E 04         0.600000E 03
```

## GAS COMPOSITIONS

OXYGEN METER CALIBRATION

VOL. PERCENT O2 = 0.2182 + 384.1279V

CARBON DIOXIDE METER CALIBRATION

VOL. PERCENT CO2 = 0.03744+133.20V-404.0V*V +25407.0V*V*V

CARBON MONOXIDE METER CALIBRATION

VOL.PERCENT CO = 0.070610 -32.142V + 11747.0V*V-227940.0V*V*V + 1644900.0V*V*V*V

TABLE OF STACK GAS COMPOSITIONS IN PERCENT, TIME IN SECONDS

| TIME | CO | CO2 | O2 | TIME | CO | CO2 | O2 |
|---|---|---|---|---|---|---|---|

```
                    TABLE OF FUEL BED COMPOSITIONS, FROM POSITION 1, IN PERCENT, TIME IN SECONDS

   TIME            CO              CO2             O2              TIME            CO              CO2             O2
0.154000E 04   0.254736E 00   0.333646E 01   0.182483E 02   0.155333E 04   0.371490E 00   0.307326E 01   0.173660E 02
0.156000E 04   0.391659E 00   0.402070E 01   0.167753E 02   0.157000E 04   0.496022E 00   0.440043E 01   0.100566E 02
0.158000E 04   0.779966E 00   0.479894E 01   0.156954E 02   0.159000E 04   0.719573E 00   0.406073E 01   0.159419E 02
0.163333E 04   0.117743E 01   0.675436E 01   0.166211E 02   0.172000E 04   0.365407E 01   0.109001E 02   0.840064E 01
0.173000E 04   0.373802E 01   0.110299E 02   0.926766E 01   0.176000E 04   0.366610E 01   0.117104E 02   0.931660E 01
0.175000E 04   0.631161E 01   0.125966E 02   0.791370E 01   0.193333E 04   0.581009E 01   0.186301E 02   0.275319E 00
0.191000E 04   0.681577E 01   0.179974E 02   0.713216E 00   0.192000E 04   0.719804E 01   0.183213E 02   0.679016E 00
0.207000E 04   0.153996E 02   0.166729E 02   0.563956E-01   0.220000E 04   0.152054E 02   0.167669E 02   0.481981E-01
0.220333E 04   0.159849E 02   0.167978E 02   0.161976E 00   0.223000E 04   0.119726E 02   0.150777E 02   0.815610E-01
0.224000E 04   0.167525E 02   0.149961E 02   0.106036E 00   0.225000E 04   0.163876E 02   0.134173E 02   0.176390E 00
0.232000E 04   0.132922E 02   0.143570E 02  -0.355377E 00   0.233333E 04   0.133157E 02   0.145156E 02  -0.356377E 00
0.254000E 04   0.123102E 02   0.146479E 02  -0.356377E 00   0.235000E 04   0.100057E 02   0.151369E 02  -0.403129E 00
0.291000E 04   0.790272E 01   0.166889E 02   0.599157E-01   0.292000E 04   0.863004E 01   0.163012E 02   0.999157E-01
0.293333E 04   0.861106E 01   0.162575E 02   0.401931E-01   0.333000E 04   0.104007E 02   0.164291E 02  -0.139366E 00
0.334000E 04   0.101679E 02   0.162005E 02  -0.783401E-01   0.335000E 04   0.100557E 02   0.163611E 02  -0.127647E 00
0.336000E 04   0.950329E 01   0.163260E 02  -0.926700E-01   0.337333E 04   0.939110E 01   0.163090E 02  -0.837561E-01
0.338000E 04   0.912997E 00   0.168171E 02   0.481931E-01   0.375000E 04   0.824650E 00   0.164505E 02   0.736532E 00
0.376000E 04   0.729644E 00   0.159909E 02   0.124207E 01   0.377000E 04   0.952966E 00   0.163205E 02   0.912154E 00
0.378333E 04   0.117793E 00   0.146317E 02   0.196763E 01   0.379000E 04   0.846775E-01   0.141144E 02   0.382094E 01
0.380000E 04   0.513712E-01   0.136030E 02   0.490906E 01
```

```
                    TABLE OF FUEL BED COMPOSITIONS, FROM POSITION 2, IN PERCENT, TIME IN SECONDS

   TIME            CO              CO2             O2              TIME            CO              CO2             O2
0.237333E 04   0.493531E-01   0.356348E 01   0.172162E 02   0.238333E 04   0.489934E-01   0.365615E 01   0.172383E 02
0.239000E 04   0.537864E-01   0.856935E 01   0.171263E 02   0.240000E 04   0.497275E-01   0.127055E 02   0.102099E 02
0.265000E 04   0.263457E 01   0.172762E 02   0.219172E 00   0.269000E 04   0.199698E 01   0.168872E 02   0.963946E 00
0.273333E 04   0.261923E 01   0.170218E 02   0.162232E 01   0.271000E 04   0.330491E 01   0.171861E 02   0.832878E 00
0.232000E 04   0.533328E 01   0.167654E 02   0.621504E 00   0.312000E 04   0.471818E 01   0.183918E 02  -0.807561E-01
0.313333E 04   0.393536E 01   0.185737E 02  -0.315239E 00   0.314333E 04   0.481133E 01   0.183335E 02  -0.244873E 00
0.352000E 04   0.849650E 01   0.169246E 02  -0.162815E 00   0.353000E 04   0.659403E 01   0.164208E 02  -0.215567E 00
0.354333E 04   0.332040E 01   0.168645E 02  -0.164676E 00   0.355000E 04   0.893430E 01   0.168396E 02  -0.192121E 00
0.356333E 04   0.639555E 01   0.173115E 02  -0.234012E 00   0.398000E 04   0.616036E-01   0.523672E 01   0.143707E 02
0.399000E 04   0.629596E-01   0.649396E 01   0.146304E 02   0.400000E 04   0.636367E-01   0.459810E 01   0.146935E 02
0.431333E 04   0.650422E-01   0.417579E 01   0.156752E 02   0.437333E 04   0.566473E-01   0.711030E 00   0.199126E 02
0.438000E 04   0.562548E-01   0.690531E 00   0.200207E 02   0.439000E 04   0.578495E-01   0.612896E 00   0.200012E 02
0.440000E 04   0.576899E-01   0.582876E 00   0.200987E 02   0.441000E 04   0.578295E-01   0.639902E 00   0.230397E 02
```

```
SLOPE OF LOAD CELL CALIBRATION CURVE = 0.103326 MV/V/LB


WEIGHT LOSS IN LBS. TIME IN SECONDS

TIME           POUNDS          TIME           POUNDS          TIME           POUNDS          TIME           POUNDS
[illegible]

THE FUEL WEIGHT IS   62.7336 LBS.
THE FULL AND EMPTY FUEL AND SECTION WEIGHTS ARE       1076.440       1013.737LBS.
```

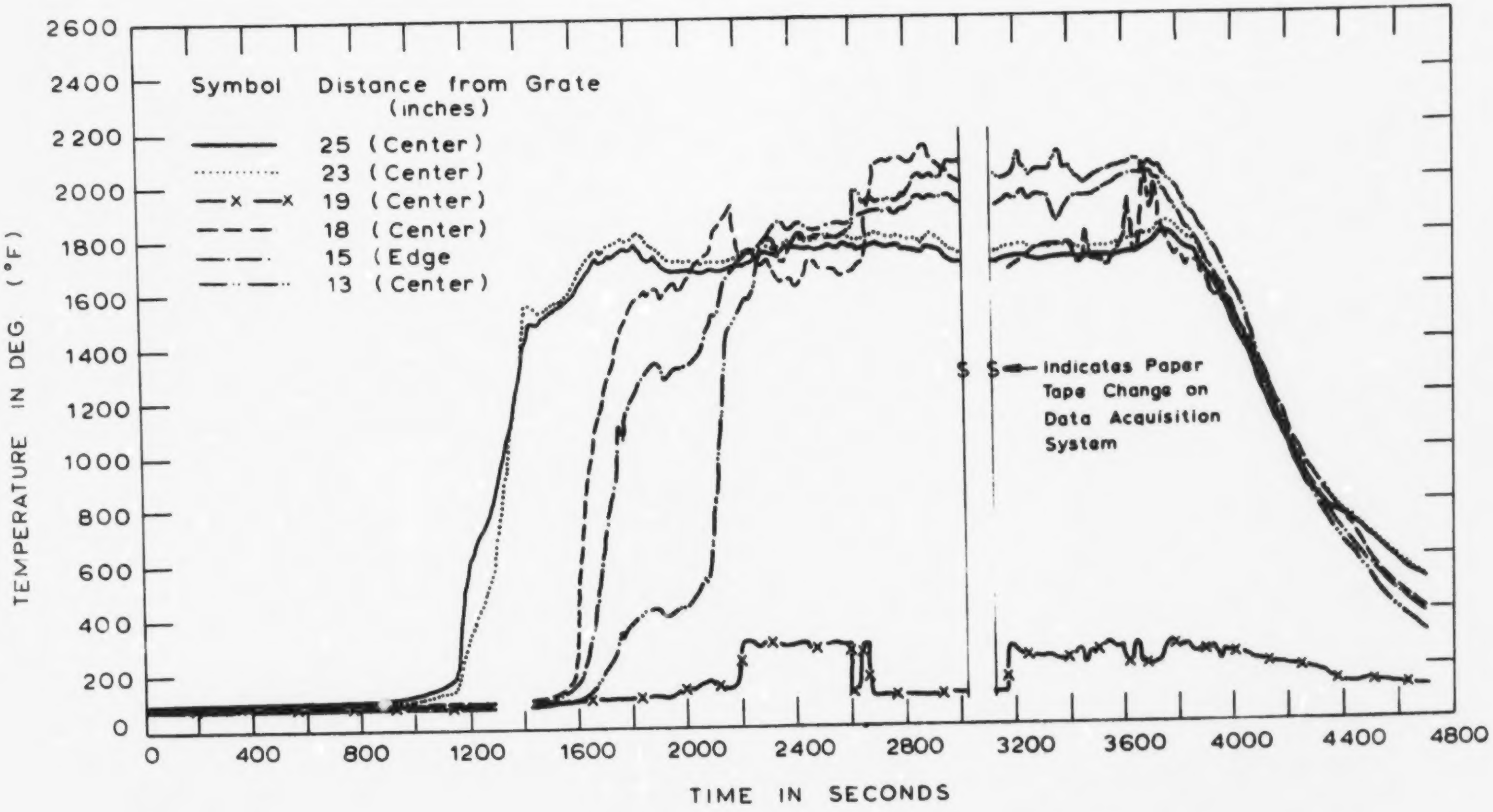


Fig. H.1. Fuel Bed Temperatures (Run 17)

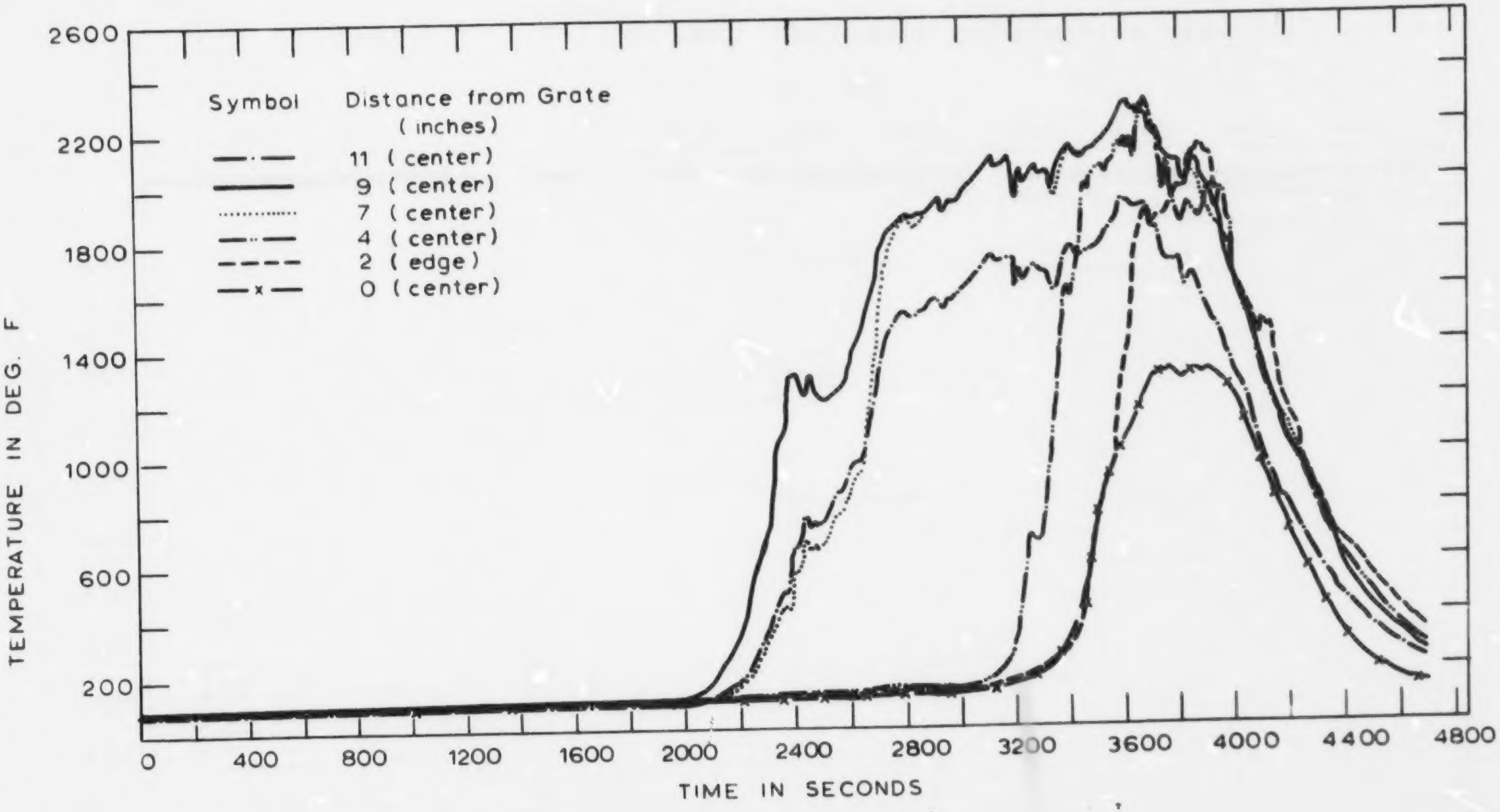


Fig. H.2. Fuel Bed Temperatures (Run 17)

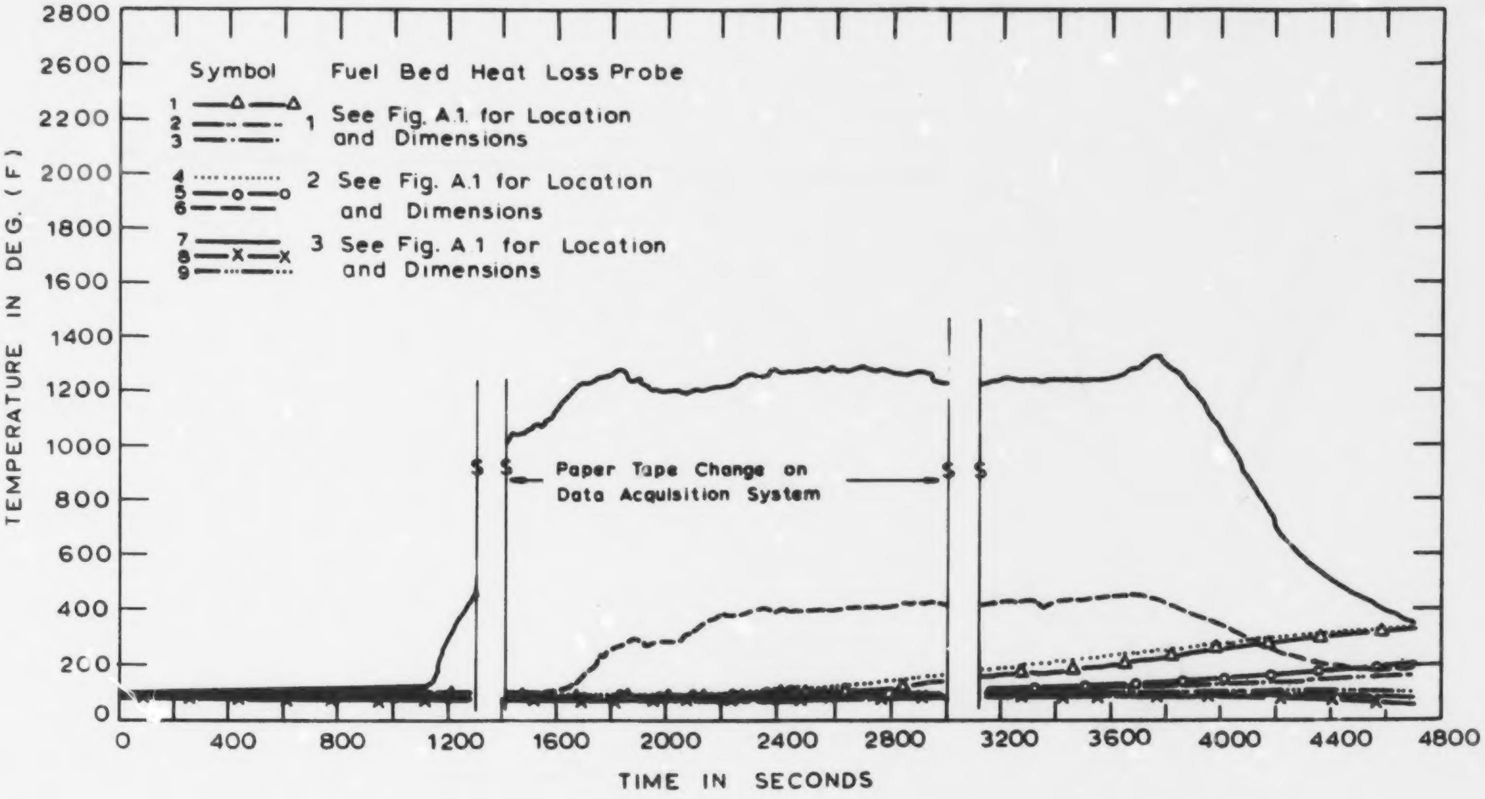


Fig. H.3. Fuel Bed Heat Loss Probe Temperatures (Run 17)

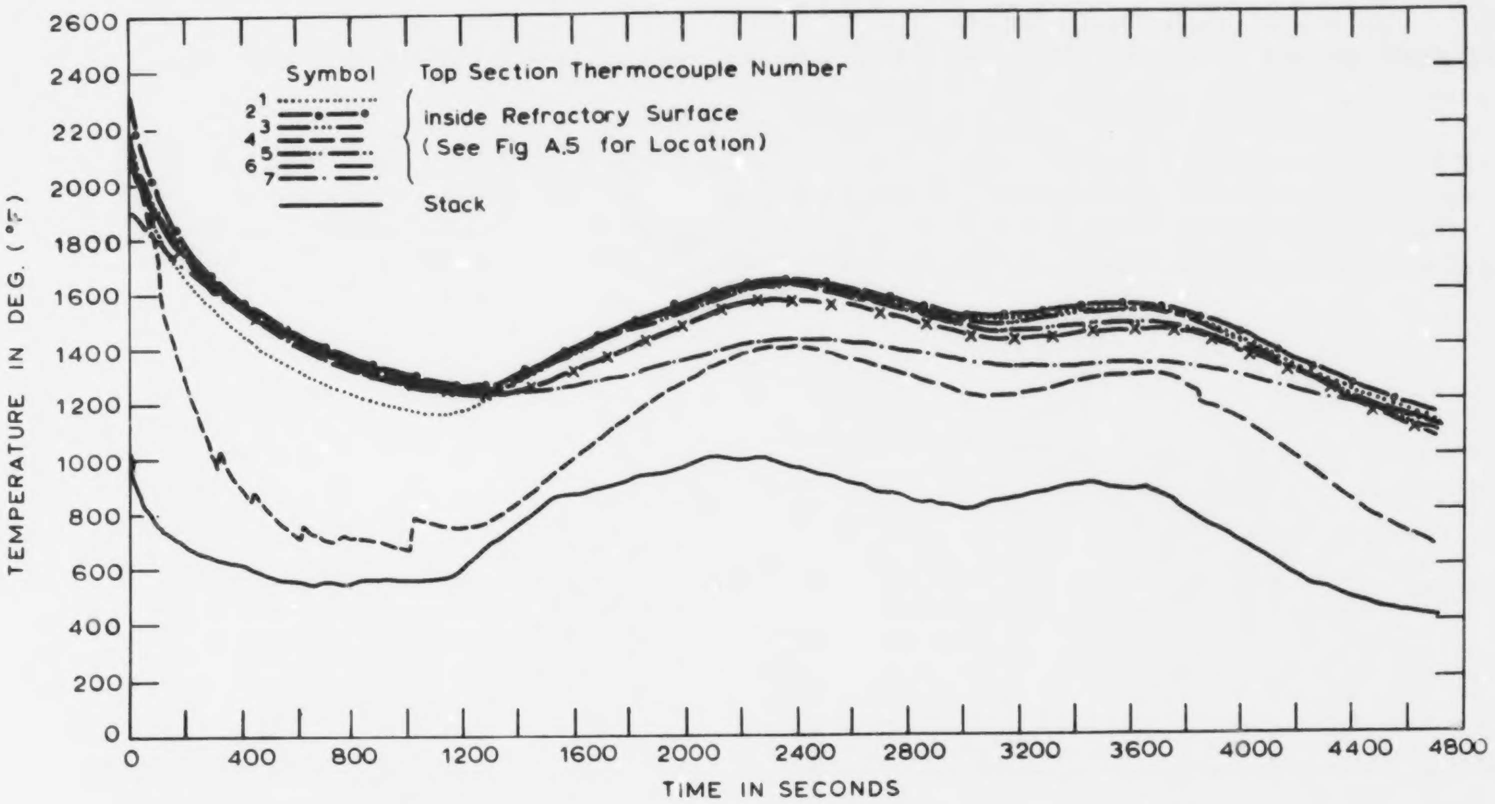


Fig. H.4. Overfire Refractory Temperatures (Run 17)

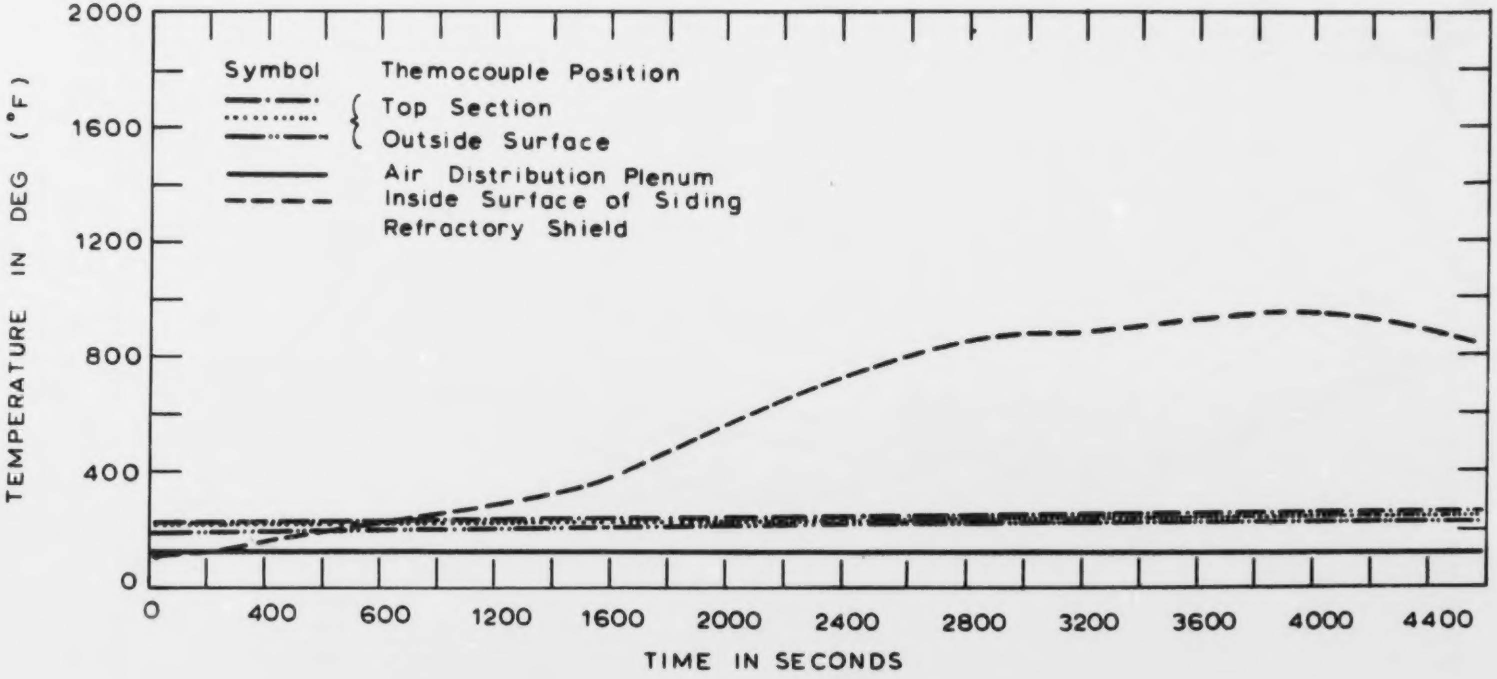


Fig. H.5. Overfire Shell, Inlet Air and Refractory Shield Temperatures (Run 17)

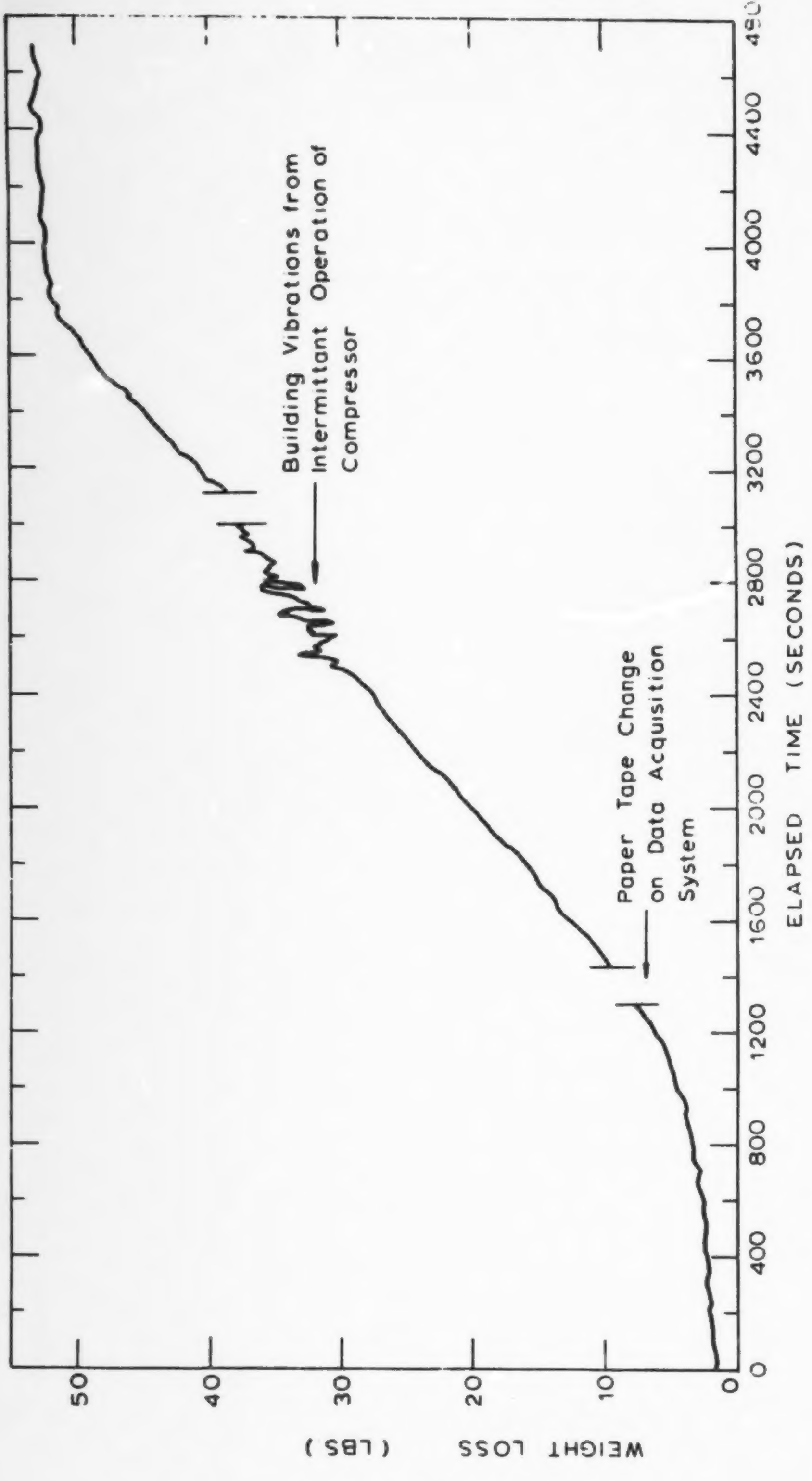


Fig. H.6. Fuel Bed Weight Loss (Run 17)